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LONG TERM RESULTS OF ORTHODONTIC TREATMENT

By **K. E. PRINGLE,** F.D.S. R.C.S. (Eng.), D.Orth. R.C.S. (Eng.)

Members of this Society have had the privilege since the first Monday of January, 1946, year by year and almost month by month, of taking part in a revolution in thought on orthodontic matters. Rix, Whillis, Ballard, Gwynne Evans, Hovell, Tulley, Nicol, Walther, and others have each made important contributions. I am sure that all the pioneers would admit that they have occasionally been at fault, in one way or another, but all have shown the same general understanding of the orthodontic problem.

Gradually, too, it has been possible to correlate the primarily English work on oromuscular behaviour with that on the skeletal development of the jaws based on cephalometric radiographs the main development in which has come from the United States. Ultimately jaw development and relations and the pressure resulting from oromuscular behaviour, particularly during swallowing, hold a very important place among the main general conditions determining the position of the teeth. Also, when we think that we can improve the situation, it is very largely jaw development and relations and the pressure resulting from oromuscular behaviour during swallowing which decides whether we can in fact do so permanently.

We must not forget mastication and the many other factors involved in one combination or another in producing a malocclusion, but speaking in a general sense I think that most of you will agree that what I have said is correct. I know there are those who remain not quite convinced. For me there were never these doubts and difficulties.

I knew by 1939 that there were at work in many orthodontic cases factors which I did not understand and I still had many questions unanswered. Then in 1944, or even earlier, Mr. Rix mentioned to me in the Children's Department at Guy's that he was watching and checking the way his patients swallowed and that some of them did so with their teeth apart. Immediately a whole series of questions was answered, but not all. As time passed more contributions were made to these studies and each of those I have mentioned has focused attention on at least one aspect of the problem and has helped me to understand something which I had not hitherto understood. With the common understanding which has arisen among us it is becoming increasingly difficult to say just who said "what" first. Having no claims to original thought myself, I can only refer you to all the Transactions of the Society since 1946 and make specific references where possible.

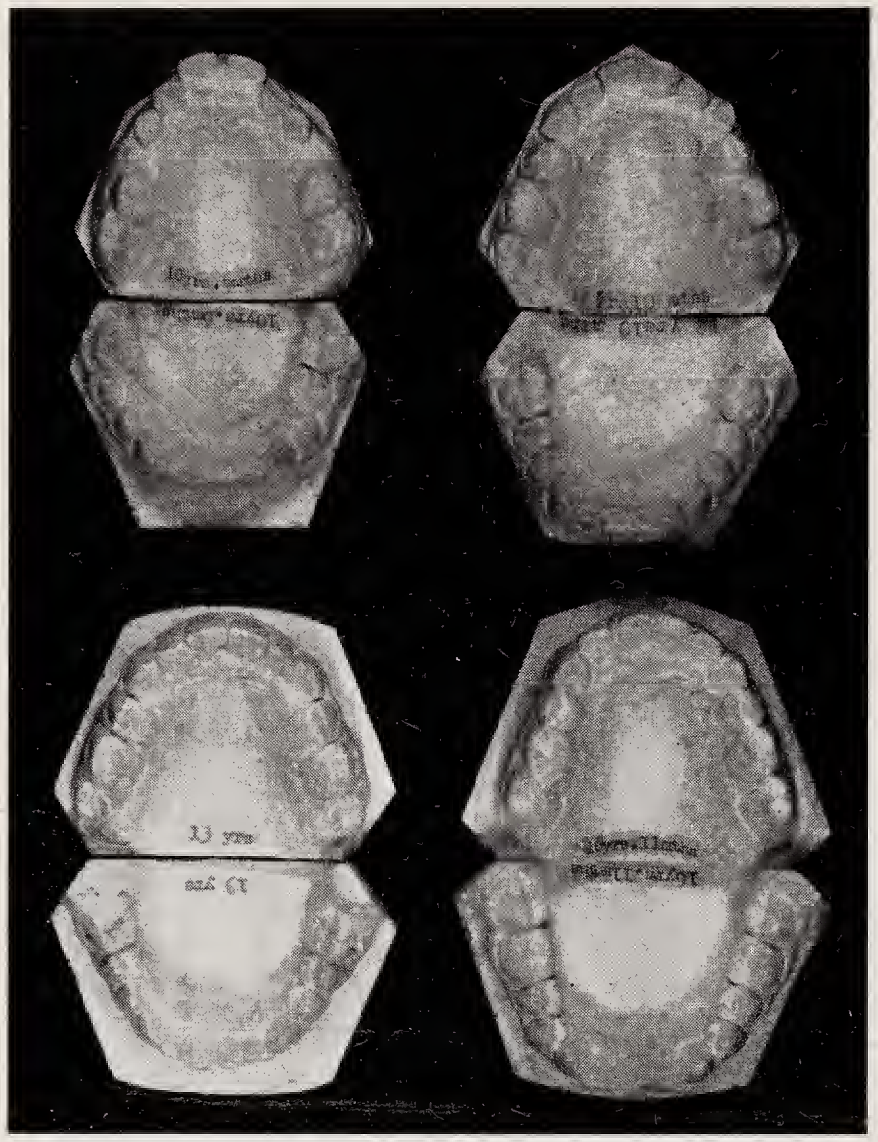
I said that there were those who are still not entirely convinced about this revolution in orthodontic thought. Perhaps this is because thought has sometimes been ahead of evidence and on occasions, too, the evidence, when it has been produced, has proved an earlier conception to be an overstatement. Again every piece of so-called scientific research based on the use of a new piece of apparatus, while perhaps helping towards a general understanding of a problem, must necessarily introduce errors leading to misunderstanding. Thus up to a point we are right to maintain a critical attitude towards any new theories or conceptions, particularly when they are put forward without much or any evidence.

My view is that the time for advancing new theories and concepts has now passed and as far as relating malocclusion to jaw development and relations and oromuscular behaviour is concerned, the next period, which will take a number of years, must be occupied here with production of evidence. We are entering a period of consolidation.

The evidence I am bringing forward to-night is simple. It consists of an analysis of ten cases. All but two of the patients had treatment at a time before 1946. So oromuscular

Presidential address given at the meeting held on January 10, 1955.

behaviour as a factor was barely considered when treatment commenced. A number of the models being ten to twenty years old, have had to be duplicated, and if we have made any



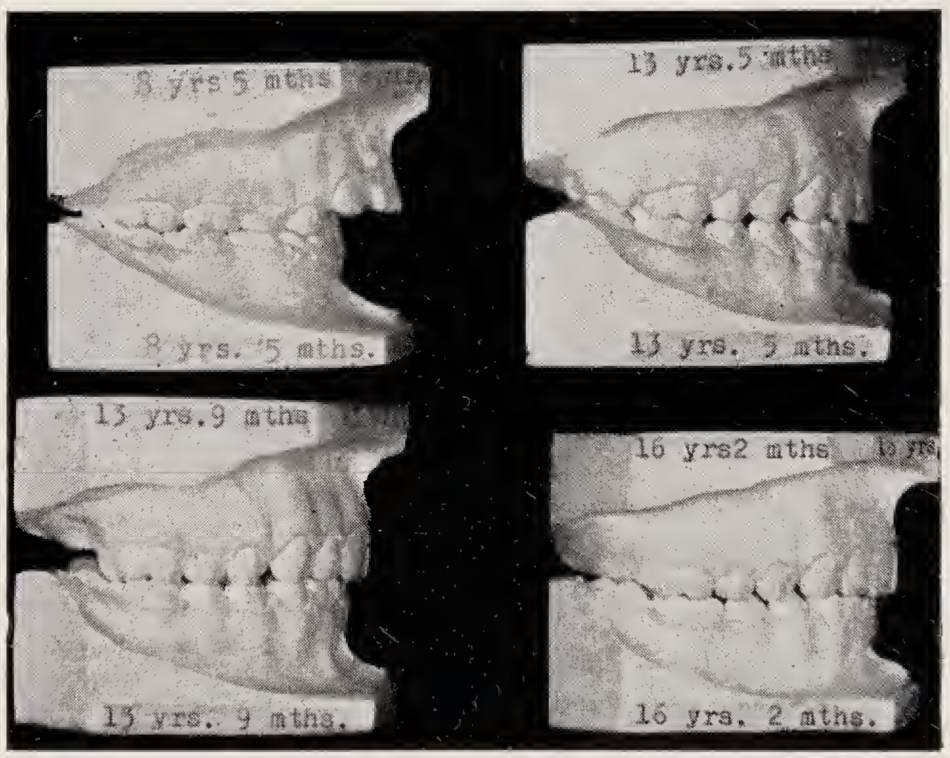


Fig. 2.—*Case* 2, treated by monobloc and extraction of $\underline{7|7}$.

minor errors in angulation of incisor teeth we offer our apologies. As we go through the cases I shall comment on various technical errors and their results in the hope that others may avoid them.

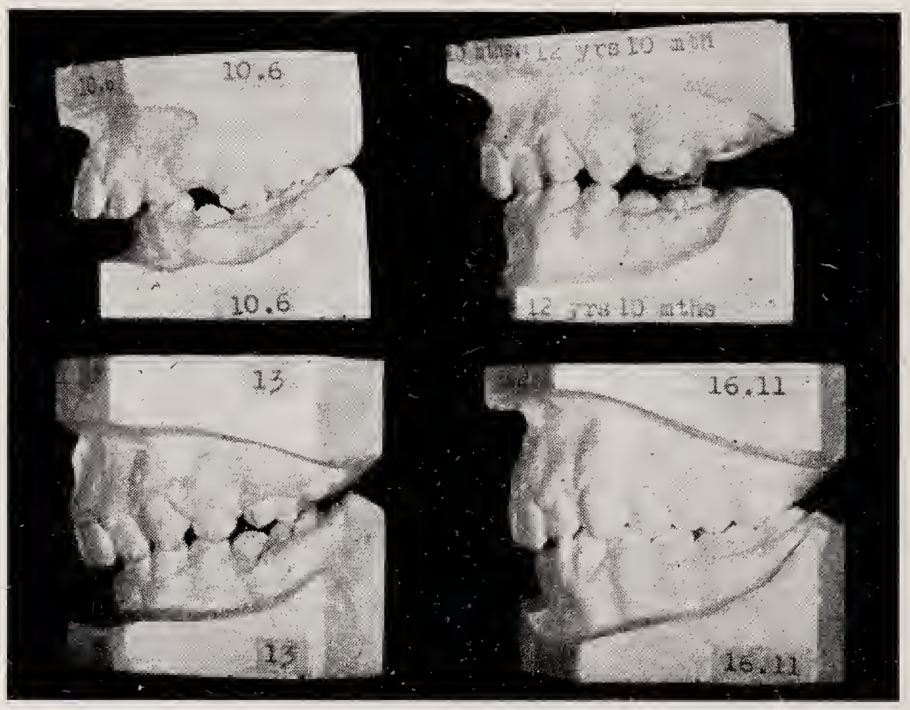


Fig. 1.—*Case* 1, treated by extraction of $\underline{5|5}$ and monobloc.

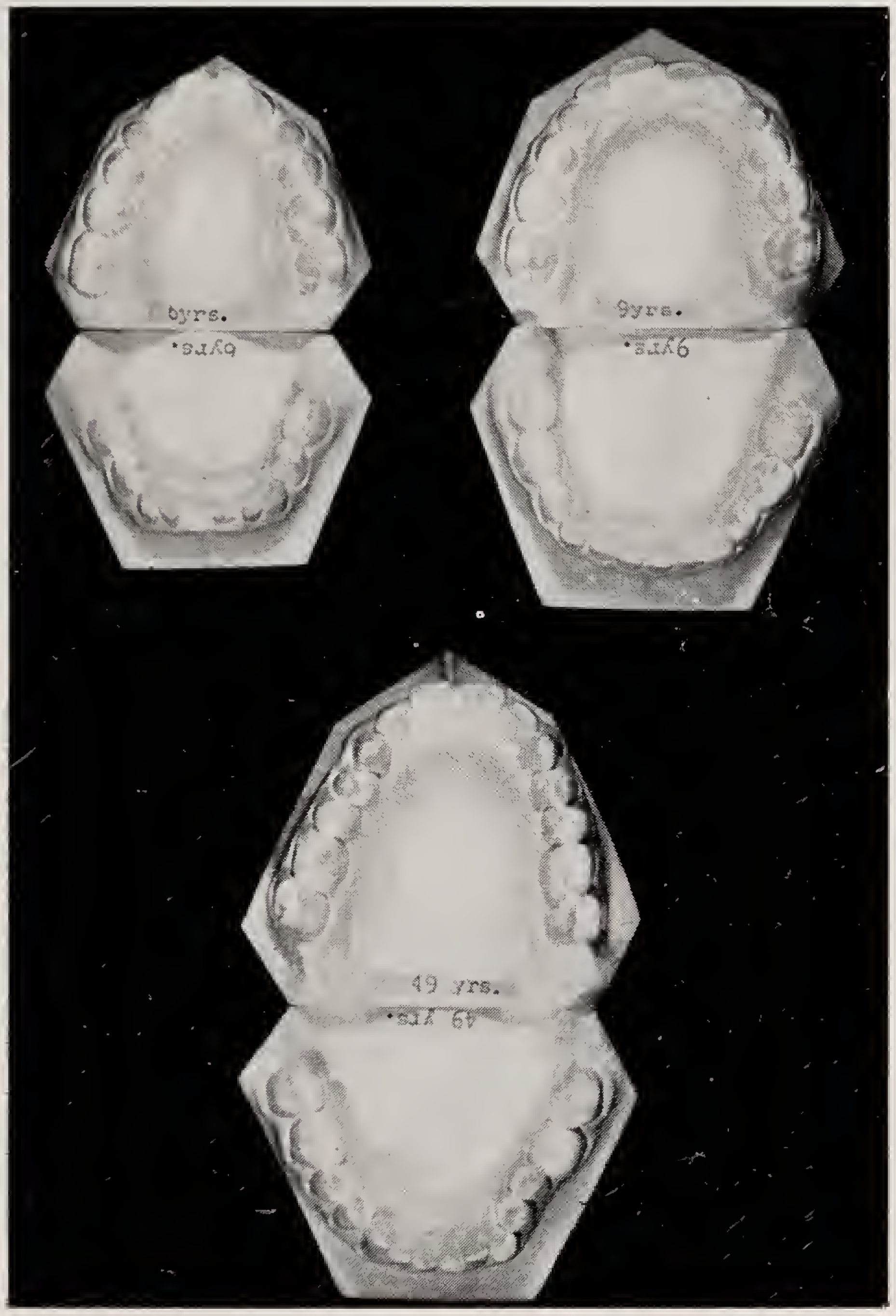
A young orthodontist does not have to bother much when he is treating a Class II, Division 1 case about what will happen after he has finished his skilled treatment, but a middle-aged orthodontist occasionally watches what were his best results at 12 years of age gradually changing into mediocre ones.

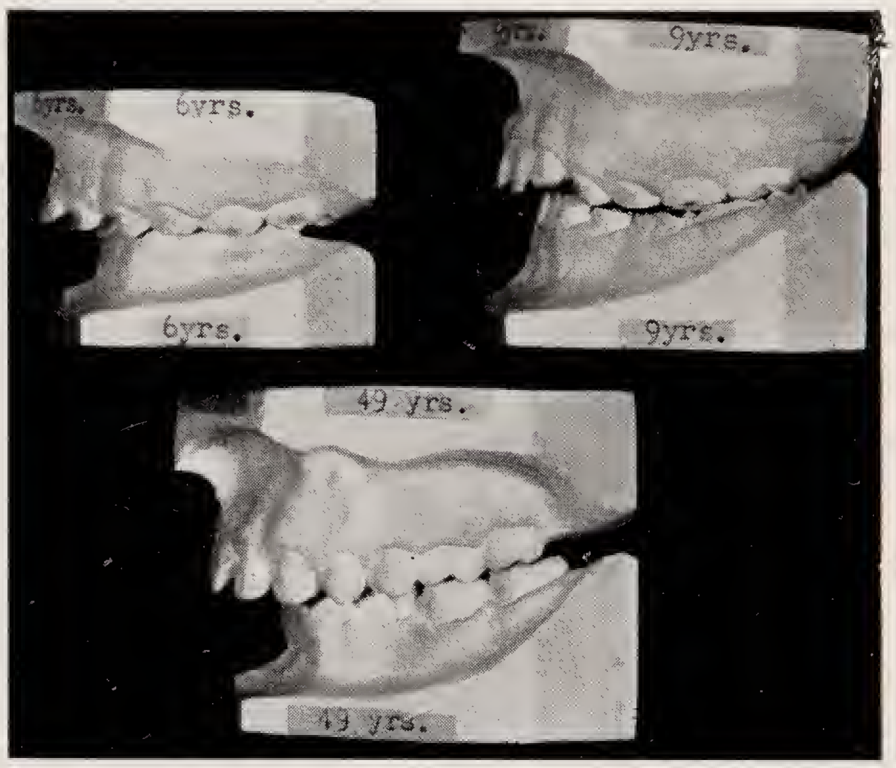
Three cases are presented which focused my attention on this:—

Case 1 (*Fig.* 1).—This is a case from my practice. For various reasons the patient's attendances were poor and I was glad to obtain by the aid of the extraction of $\underline{5|5}$ and a monobloc this result at 13 years, particularly after a halfway stage, which showed me for the first time what can happen to the bite if a monobloc is worn for a long period without trimming (age 12.10). After the boy had disappeared with his untrimmed monobloc for several months he returned without one back tooth capable of meeting its opponent. As soon as his front teeth were straight and his monobloc removed the boy disappeared again, and thinking that all was reasonably well I was quite happy to let him do so. I simply had not appreciated the signs of future collapse in the lower dental arch. Some years later his dental surgeon referred him to me again

because of the crowding of the lower incisors (age 16.11). That was about three years ago. Even as recently as that I thought it was the third molars which were at fault more than anything else.

During treatment the measurement between the upper first molars and the upper central incisors decreased by 6–7 mm. Since the end of treatment to the most recent models (about $3\frac{1}{2}$ years) there has been a continued decrease of 2–3 mm. The lower arch in the same region has also decreased by 2 mm.





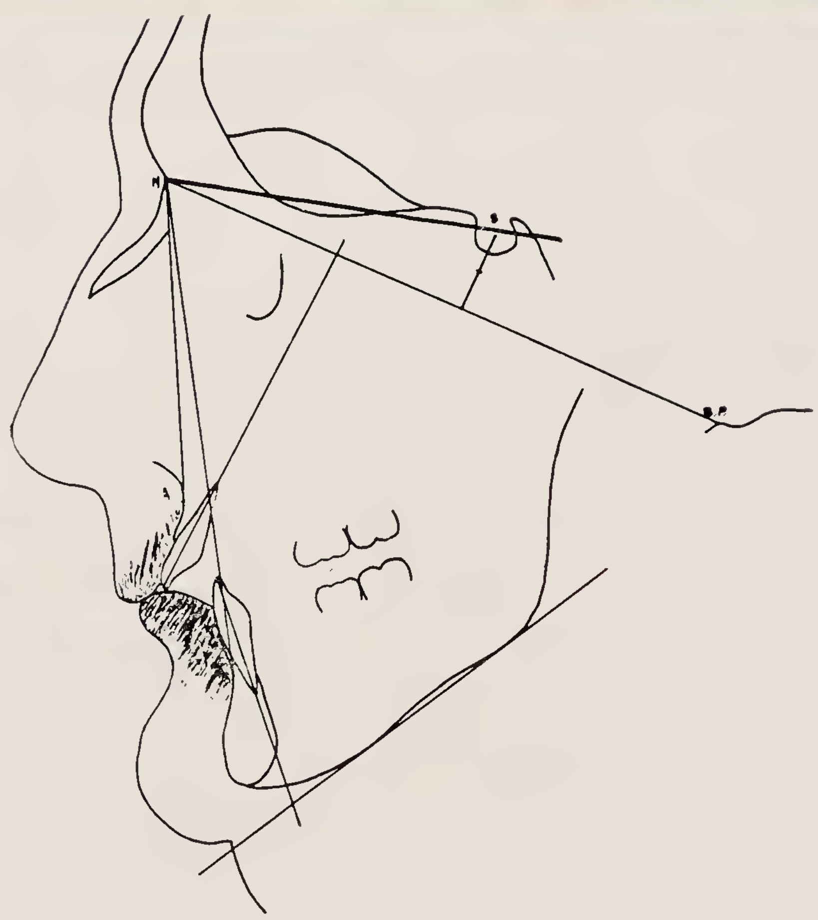


Fig. 3.—*Case* 3, father of *Case* 2. Note lip seal.

Case 2 (*Fig.* 2).—Some years ago a young girl was referred to me at my practice for orthodontic treatment (age 8.5). There had been thumb-sucking and she certainly lisped. I suspected that she swallowed with teeth apart and the tongue advancing over the lower incisors, to seal with an indrawn lower lip. The child was very intelligent and the parents were most helpful. The father told me that he had been treated by Mr. Chapman, who had obtained an excellent result for him, but that when he was about twenty years old the teeth had started to move back to their old positions. I did not examine his mouth at that time but made a mental note that he lisped and that he had a Class II, Division 1 occlusion with a definitely postnormal mandible (Ballard skeletal 2) and that he probably swallowed with teeth apart and the tongue advanced to seal with an indrawn lower lip. (I am using the skeletal classification and

Angle's classification rather loosely throughout as a kind of orthodontic shorthand.)

The child's treatment, which was by monobloc, went well except that the occlusion was perhaps a third of a unit out on the right side. As a precaution I had $\underline{7|}$ extracted (age 13.5). However when we left off the monobloc (age 13.9) she came back saying that her teeth were "going back". By the evidence of models this was not true, as her occlusion from being not quite "normal" had settled into being "normal" all round the mouth (age 16.2). She still lisps and her tongue is still in evidence, but the lower lip is brought well up the labial side of the upper incisors when she swallows. I am still keeping her under observation with some interest. At the moment $\underline{|1}$ is a trifle more proclined than $\underline{1|}$ and I am now recommending extraction of $\underline{|7}$.

Case 3 (*Fig.* 3) (The father of *Case* 2).—After asking Mr. Chapman's permission, I recently had the opportunity to examine the father. By great good fortune Mr. Chapman was able to lend me models of the boy before treatment at 6 years and on August 1, 1914, at 9 years of age. One can see that at that time his treatment with intermaxillary traction was proceeding well. One can see from the first models of the temporary dentition the severity of the Class II, Division 1 condition. One can see also the retroclination of $\overline{1|1}$ as they erupt. I am sure it was as difficult a case of its kind as one could find.

We have no history of the case after 9 years of age, but the treatment was clearly satisfactory to the parents and the boy, until he was about 20 years old. Then gradually and inexorably the adverse combination of poor skeletal relations and the abnormal oromuscular behaviour that went with them took their toll. The patient is now 49; $\frac{8|8}{8|8}$ were extracted at 35 years of age. My lateral radiograph taken without a craniostat gives an idea of the way he seals in the rest position. The lips seal at the level of the tip of the upper incisors. The lower lip is pulled in hard at the base of the lower incisors and is then curved forward to meet the upper lip. My original impression that he swallows with teeth apart and the tongue advanced over the lower incisors to touch the lower lip seems to be correct. An interesting feature is that when the patient is asked to bite he is still uncertain whether to bite into a more forward position than is strictly correct.

The following measurements are of interest. In the last forty years (ages 9–49) the distance between the upper first molars and the upper incisors has slightly decreased. The same measurements in the lower arch have decreased by 4–5 mm. It is the lower arch which has collapsed, and I think the false forward posture of the lower jaw. If the upper teeth have advanced they have done so as a whole, not simply the incisors.

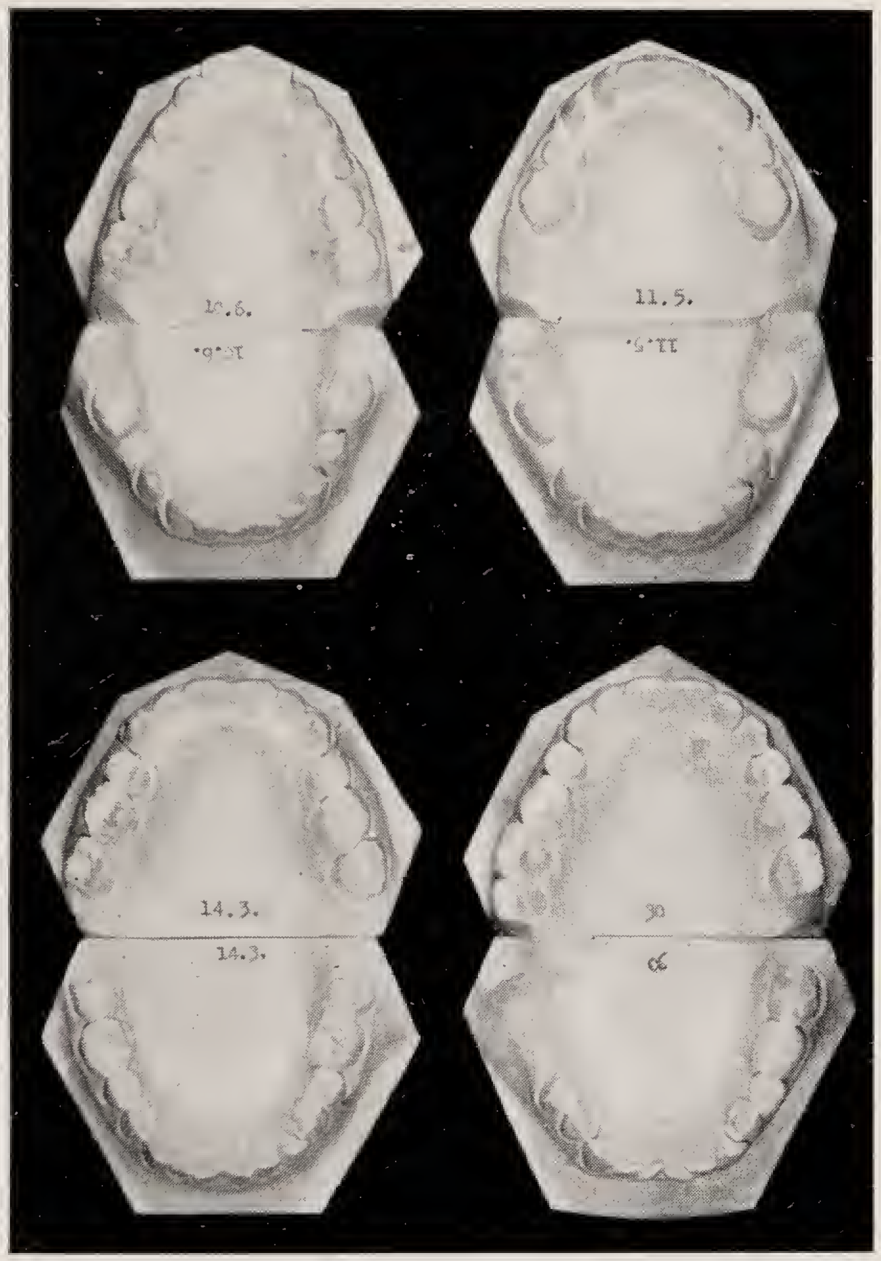
These then are the kind of problems that come as one gets older and yet if one looks at even only the next seven cases, who were all who returned to us, when we wrote to quite a few, we shall see that oromuscular behaviour can act as a factor stabilizing a result, or as a factor operating against stability in either or in both arches.

Case 4 (*Fig.* 4).—This is a case from the practice. When I was a dental student I knew the boy's parents. The father was skeletal II and Angle's Class II, Division 1, with, I should certainly say, associated abnormal swallowing habits. I do not remember whether he sealed his lips completely, but my recollection is of two front teeth showing rather a lot.

The boy used to sit in his push-chair sucking his thumb with great vigour. As a young suburban practitioner I took on his treatment with some trepidation (age 10.6). However, with the aid of extraction of $\underline{4|4}$ and intramaxillary traction with Visick's appliance, carrying cleats over $\underline{1|1}$, an excellent result was obtained in a very short time (age 11.5).

I thought the result might well have relapsed, for I am sure that originally there cannot have been what we would call normal deglutition or a normal lip seal. I was quite wrong, for when I saw him a few months ago (age 30) I found that his incisors were practically exactly the same as when treatment finished (age 14.3), but with rather a deep incisor overlap (overbite). He has grown to an immense height.

He lost one or two teeth in the Army, but otherwise his oral condition is good, with no more than the usual amount of caries. He gives the outward appearance of a mild skeletal II, with Class II, Division 2 type of



mouth, and when he swallows he seals his lips by bringing his lower lip well up the labial side of his upper incisors to seal with a shortish upper lip. I think this must have been a stabilizing factor. Nicol in his recent communication to this Society focused our attention on this question of the height up the labial side of the incisors at which the seal takes place. The crowns of the upper incisors and first molars moved about 12 mm. nearer to each other in 11 months' treatment. Since then the distances between these teeth have hardly changed.

The measurement $\underline{6|}$ to $\underline{|6}$ narrowed by 4 mm. during my treatment with intramaxillary traction, but after this they recovered themselves and now the measurement is a trifle more than at 10.6 years. Between ages 10.6 and 14.3 the measurement between $\overline{|3}$ and $\overline{|6}$ increased without help by 4 mm. to accommodate $\overline{|5}$, but this measurement has lessened by a half this amount since then, so that $\overline{|45}$ have buckled. $\overline{1|}$ has also rotated.

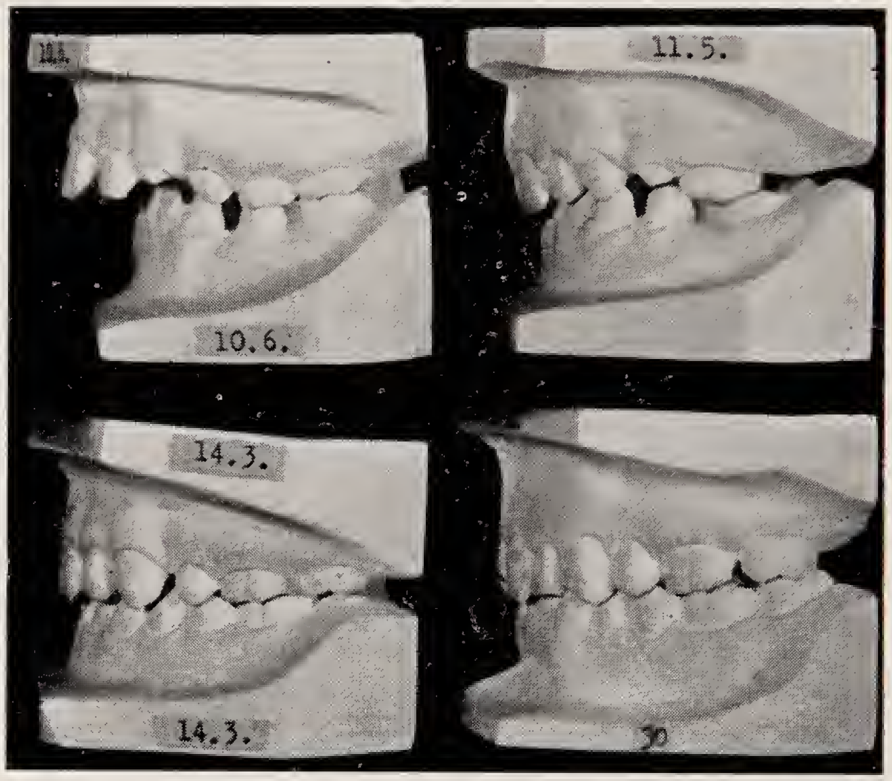


Fig. 4.—*Case* 4, treated by extraction of $\underline{4|4}$ and intramaxillary traction.

This rotation of lower incisors can of course be seen as a normal phenomenon.

As we continue to examine our cases this evening I think it will become clear that the degree to which the lower lip comes up to compensate for a short upper lip is very important. Among the medical students at Guy's is a very charming and always smiling young lady, a mild skeletal II, with $\frac{6|6}{6|6}$ extracted and with upper and lower incisors retroclined with a deep incisor overlap (overbite). When the upper lip is at rest one can see all the labial sides of the crowns of the upper incisors and a substantial amount of the gum above these teeth. Yet when the young lady swallows she brings the lower lip up to seal with the upper at a level higher than the necks of the upper incisors.

At this point I should say that I have found it more difficult with adults to establish whether they have a "tooth apart swallow" than is the case with a child, who is for the first time asked to swallow. We all know the difficulty of deciding anything about a child's

swallowing habits when several people have tried to find out before us. The adult on being asked to swallow seemingly has to think "Why does he ask me to swallow?" and this intellectual interference interrupts what should be a natural action.

Case 5 (*Fig.* 5).—My next patient is one whose upper incisors were large and extremely proclined. As you will see, he was a very nice boy. Although he had a reasonably good lower jaw and a very good lower dental arch, there was not the slightest possibility of a lip seal

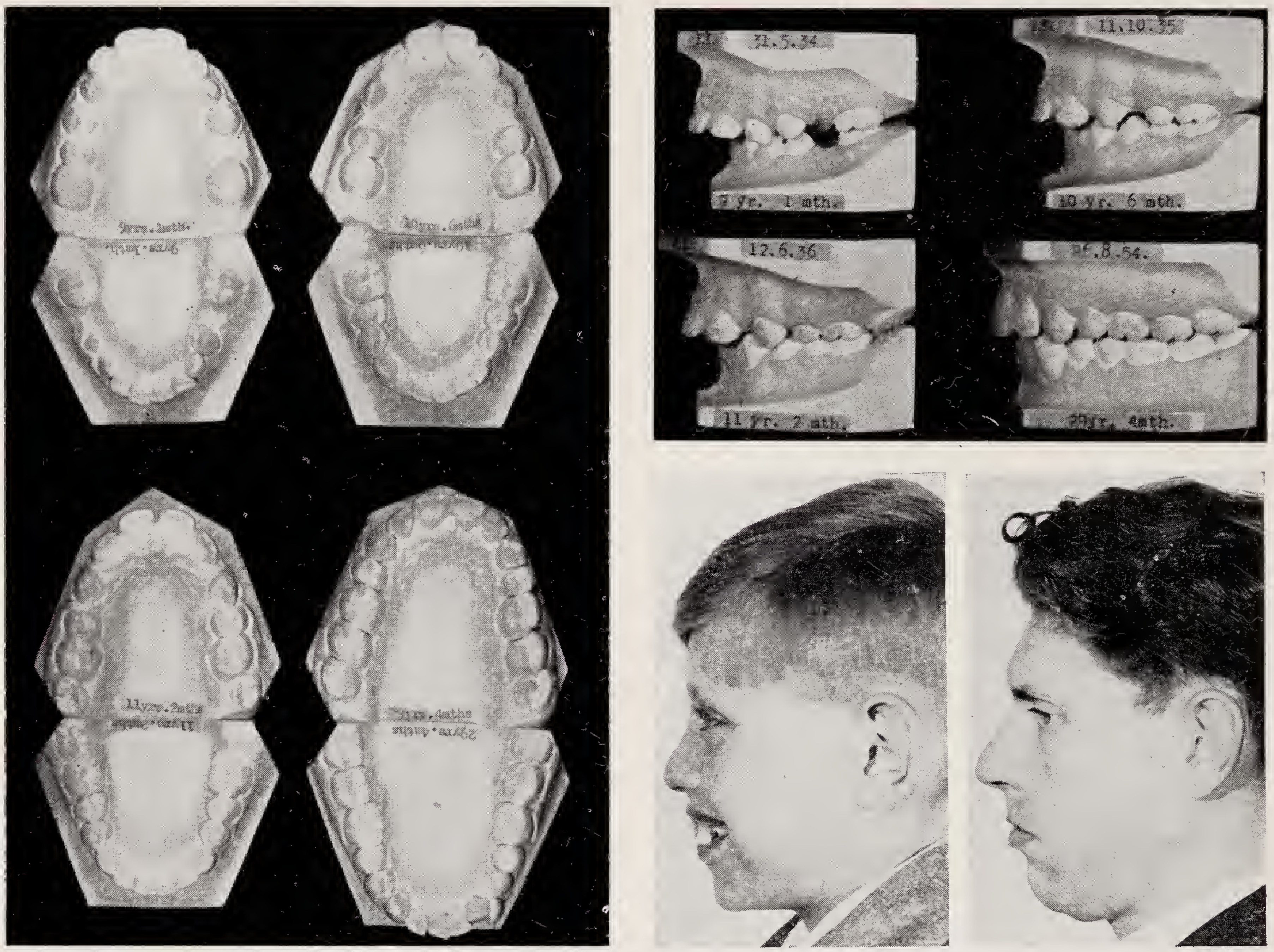


Fig. 5.—*Case* 5, treated by extraction of $\underline{4|4}$, retraction of $\underline{3|3}$, followed by retraction of $\underline{21|12}$.

before orthodontic treatment started. When he began his treatment I knew nothing of oromuscular behaviour as an aetiological factor, so that I can only guess what happened when he swallowed, but it could be that he was one of those extreme cases described by Rix who swallow with cheek teeth together or nearly so and obtain their main anterior seal when the lower lip is "trapped" between the upper and lower incisors, the upper lip remaining high and taking no active part in the seal. As I say, this is simply a guess on my part. The treatment was:—

1. Extract 4|4.
2. Retract 3|3 while using an upper bite plate.
3. Retract 21|12 with saddle upper plate and labial bow.
4. Retention.

The first models (age 9.1) show the original condition. The second models (age 10.6) the extraction of 4|4. The third models (age 11.2) show the canines retracted and, however it occurred, the raising of the bite anteriorly. The models at completion were I am afraid lost, but the result was a good one as I remember it. Some 18 years later (age 29.4), and much to my surprise, not only have the upper incisors remained in their retracted position but the lower incisors and canine regions have to a considerable extent collapsed. The overbite is now fairly deep. The young man now seals his lips at rest and swallows with a powerful lip seal, with his lower lip everted to give an extra pressure. The lower lip comes well up the upper incisors. Someone may ask whether the man now seals his lips through a conscious effort or through maturation. I do not know the answer to this question, but I watched for about an hour recently and his lips were sealed at rest.

Mr. Tulley's electromyographic report says: "No marked masseteric contraction during swallowing, indicative of a 'tooth apart swallow'. At rest the lips show active contraction when sealed and during swallowing more than usual lip activity is recorded."

I note that during treatment with the bite plane the lower occlusal plane flattened out, since then the curve has returned. I used to teach that a deep incisor overlap (overbite) at the end of treatment was an adverse factor for stability of the upper incisors. Clearly it need not necessarily be so.

Case 6 (*Fig.* 6).—Mrs. S., the next patient, sucked her thumb and came to Guy's at an early age (age 6.6), showing a typical Class II, Division 1 with an anterior open-bite abnormality in the deciduous dentition. There was a flat occlusal plane. We waited until the permanent incisors were through (age 8.5), and the treatment was then as follows, using fixed upper labial and lower lingual appliances:—

1. Proclination of 21|12 to give a better alinement of these teeth and provide premolar space.
2. Extraction of 4|4.
3. Retraction of upper incisors with intermaxillary traction.

At the end of treatment (age 12.2) everyone was happy with the result. Nine years later (age 21.9) the upper and lower incisors have kept good mutual relations. The incisor overlap (overbite) is deep and the patient gives the appearance of skeletal II, and her models resemble an Angles Class II, Division 2 type. Her lips are sealed at rest and when she swallows the lower lip seals well up the labial side of the upper incisors.

Mr. Tulley's electromyographic report says: "No marked contraction of masseter during basic swallowing, but in swallowing after chewing biscuit there was a marked masseteric contraction indicative of a tooth together swallow. Lip activity only slight compared with Case 7." (*Fig.* 8 A, B.)

The measurements show that from the beginning of treatment to the end there was an increase in the distance between |1 and |6 of 4–5 mm. From the end of treatment until now there has been a decrease in the same measurements of 6 mm. That is to say the measurements are rather less now than they were before we started the treatment of the lower dental arch. Some recent extractions may have helped this collapse or could one say double retroclination of the incisors?

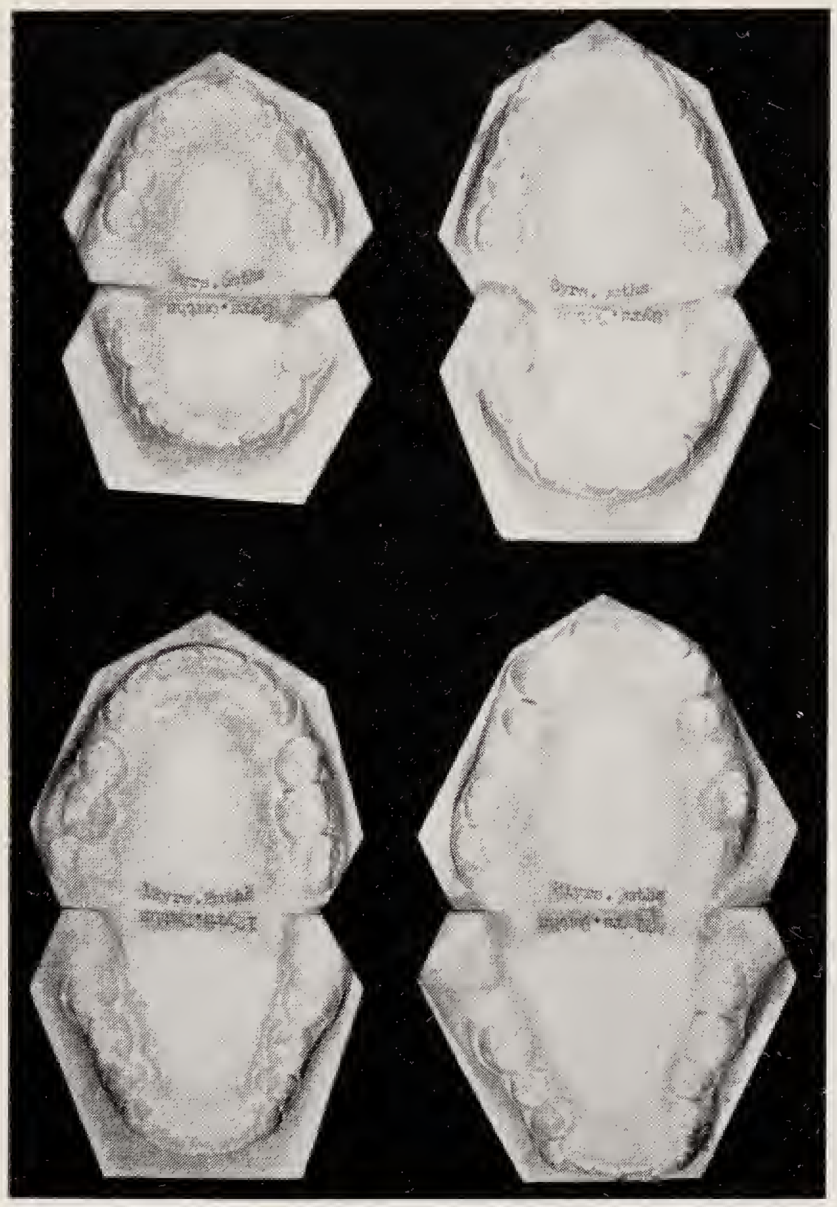
The lateral profile radiograph is interesting, for the lower incisors are still at an angle of

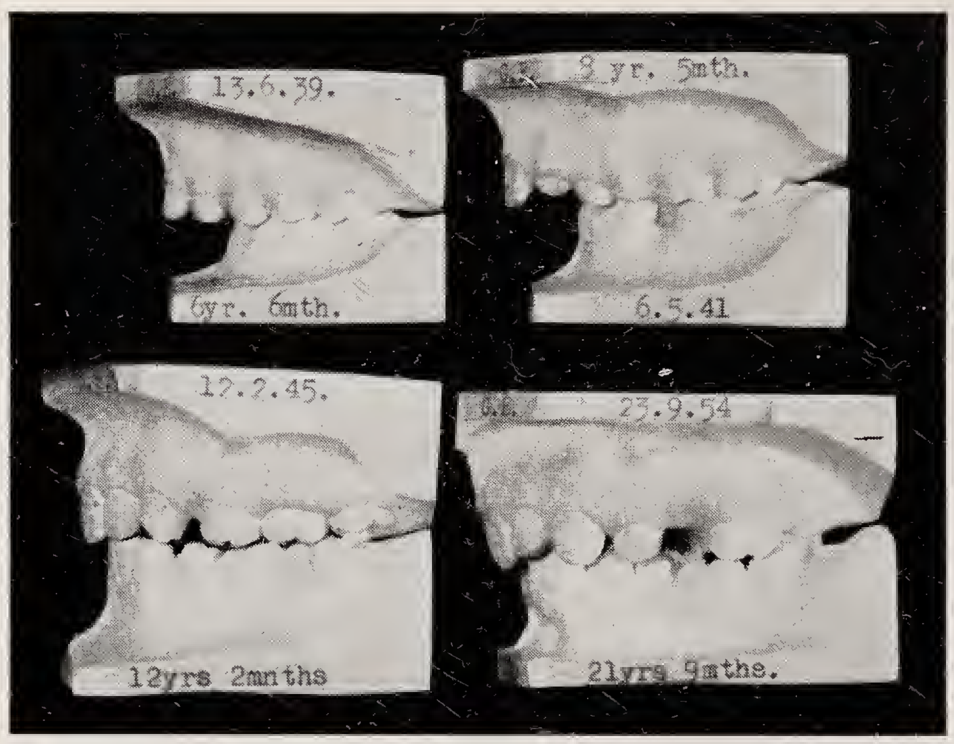
more than 90° to the mandibular plane. I feel that I still do not understand all that has happened in this case.

Case 7 (*Fig.* 7).—Mrs. C., as a girl (age 10.6) showed a teeth-apart swallow of the type where the tongue advances to seal with an indrawn lower lip everted but behind the upper incisors—a familial picture. Treatment, which was very hard work, was by:—

1. A little upper expansion.
2. Extraction of $\underline{4|4}$.
3. Intermaxillary traction with fixed appliances (age 13.11 during this stage).
4. Quite a long retention (age up to 16.8).

Six years after treatment (age 22.11) a skeletal II relationship remains and she still swallows with teeth apart and the tongue advanced to meet an indrawn everted lower lip. At this moment, however, when this anterior seal occurs the upper incisors are trapped in the lower lip at, so to say, a half-way point, so that part of the lip is in front of the upper incisors and a part behind. She is





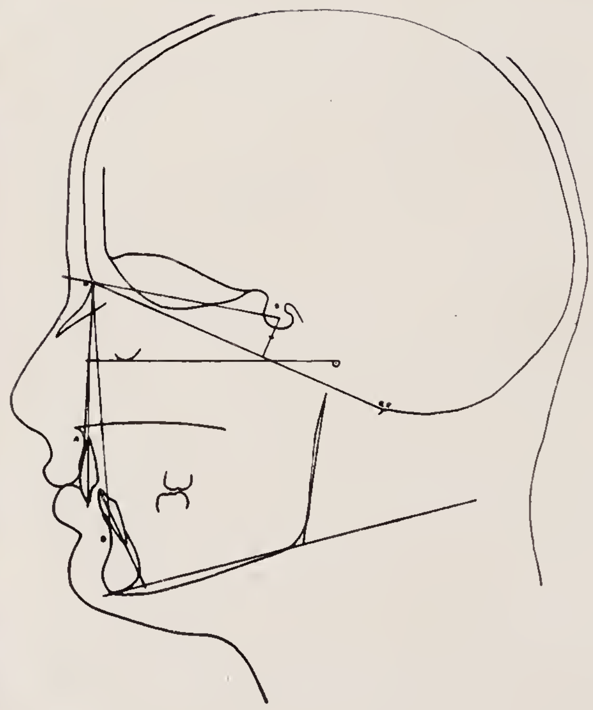
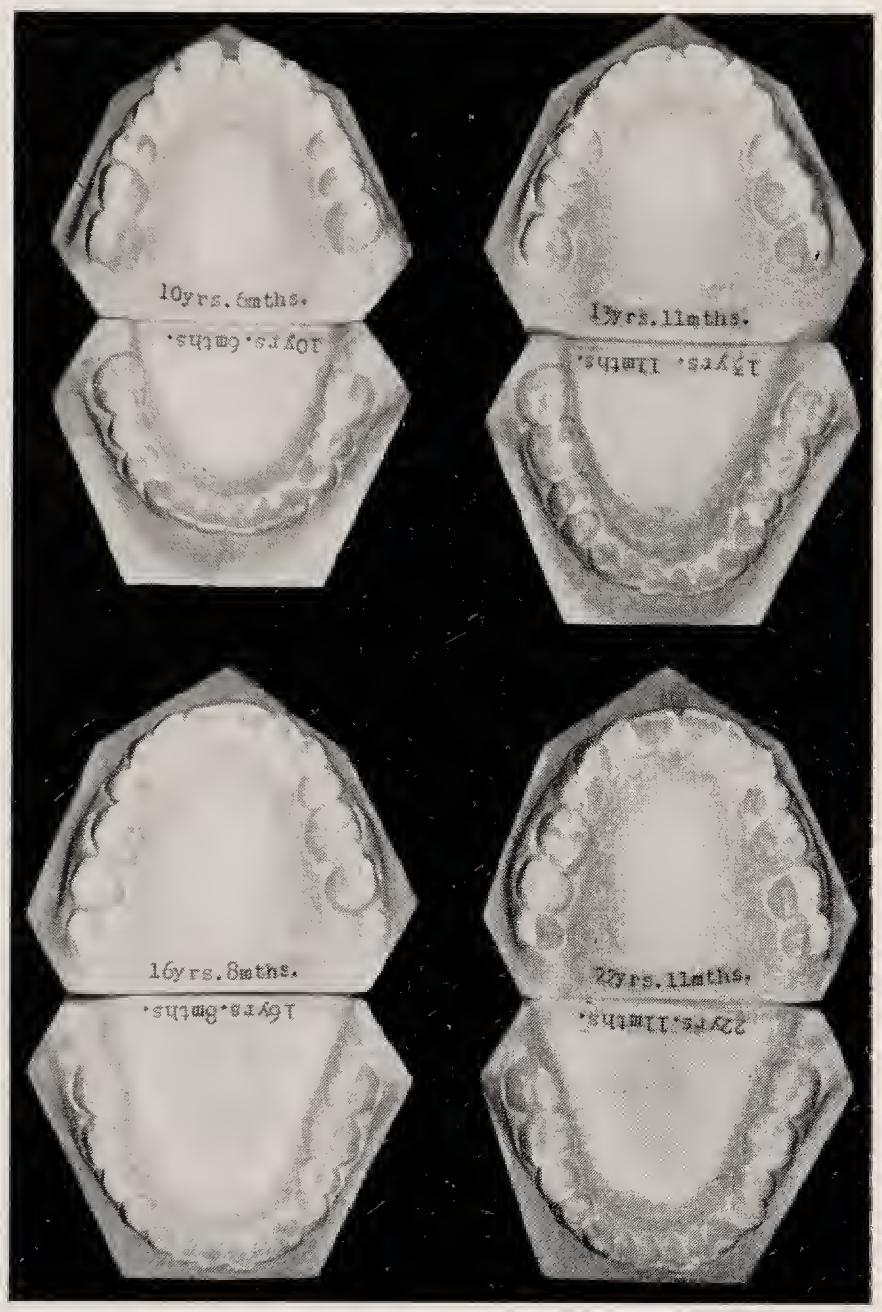


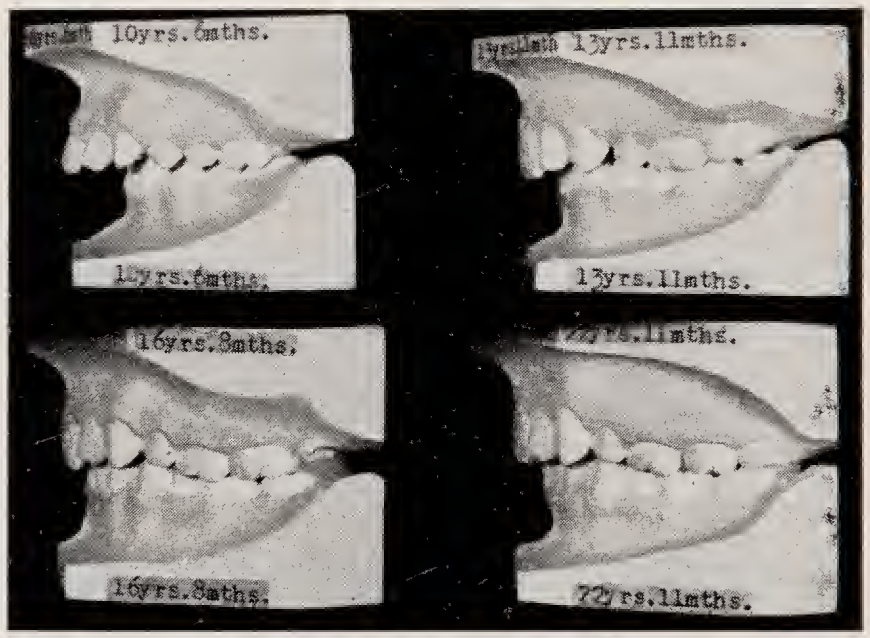
Fig. 6.—*Case* 6, treated by extraction of $\underline{4|4}$ and intermaxillary traction. (Compare lip position with *Fig.* 7.)

the only one of my cases who complains that the upper incisors are relapsing, i.e., becoming proclined again.

The measurements since the completion of treatment are interesting because the lower measurements show no change, while there has been spread of the upper incisors. The space between 1|1 has increased. This of course should be compared with the earlier cases, where the powerful lip seal is associated with a lessening of the lower measurements. This patient can seal her lips at rest, but I think that in her case this is definitely the result of voluntary effort.

The lateral tracing is perhaps as one might expect, but the electromyographic record is of interest in that this patient shows more than any of the others a marked lip activity during swallowing. Mr. Tulley's electromyographic report shows the value of having a clinician standing by the machine. He says: "There was no marked masseteric contraction in the basic or post-masticatory swallow,





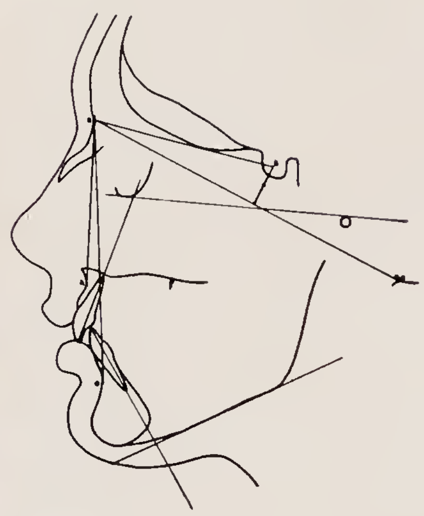


Fig. 7.—*Case* 7, treated by extraction of 4|4 followed by intermaxillary traction.

but there was evidence of considerable lip activity, particularly of the lower lip. A similar myograph has been seen in other partially relapsed Class II, Division 1 cases." (*Fig.* 8 A, B.)

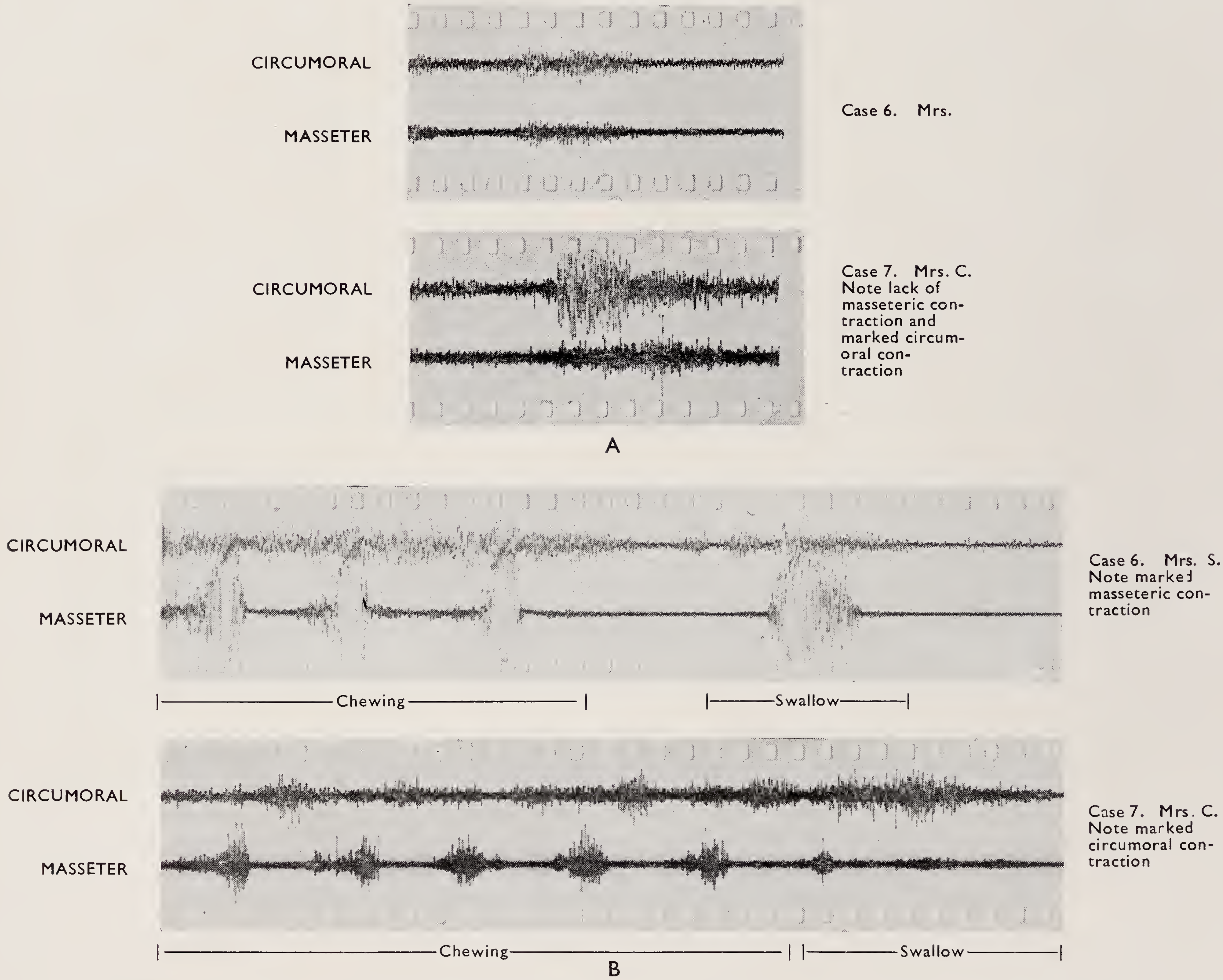


Fig. 8.—Electromyographic tracings comparing the oro-muscular behaviour in *Cases* 6 and 7. A, During the basic swallow; B, During swallowing after chewing biscuit.

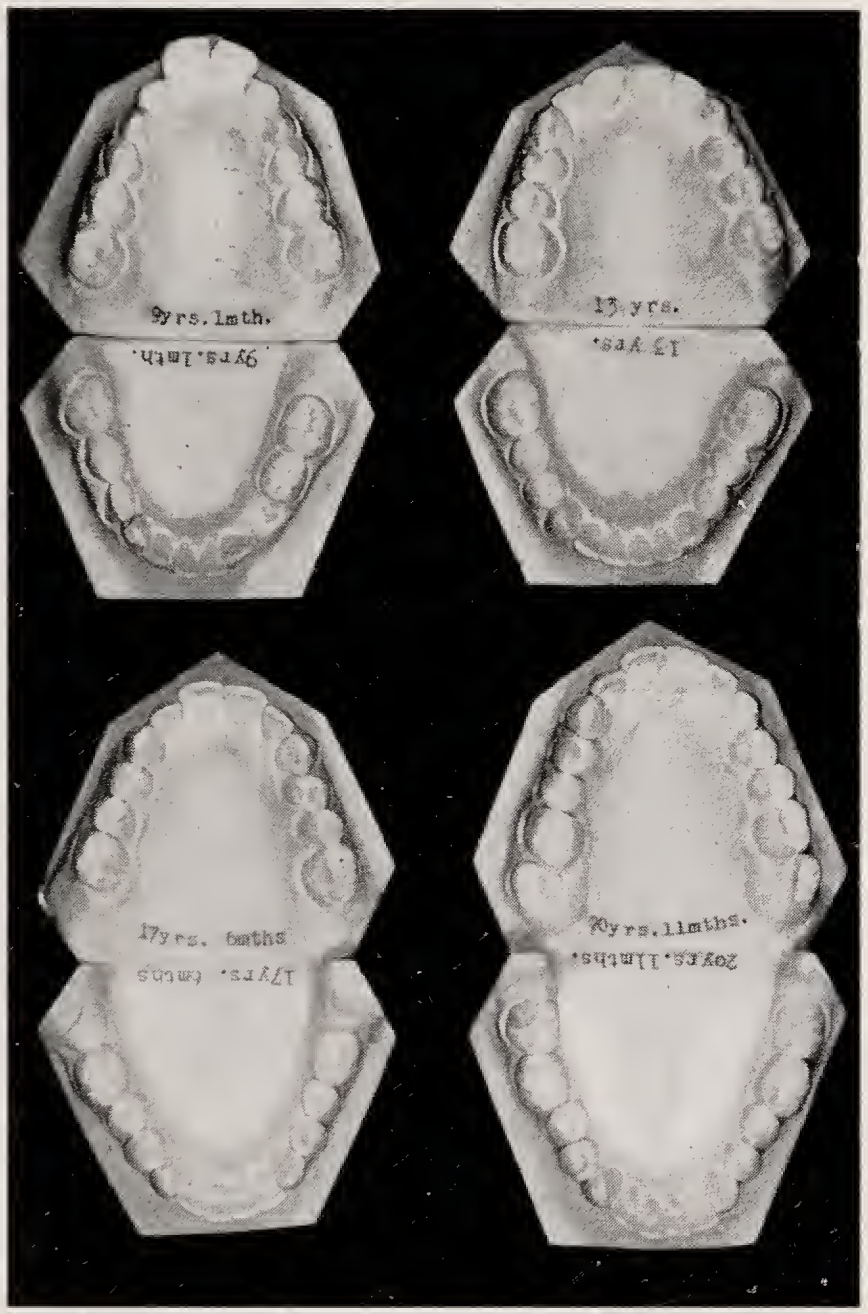
The electromyograph as yet shows only the degree of lip activity during swallowing and not whether this lip activity is in our favour or not. This latter requires a clinician. There seems to be the possibility of further research here as to the amount of pressure exerted by the lips on the incisor teeth and the amount of pressure applied to the different parts of these teeth.

Case 8 (*Fig.* 9).—In the next case there was no thumb-sucking. The patient was clinically a mild skeletal II, Angle's Class II, Division 1 (age 9.1). Treatment was by intermaxillary traction with fixed appliances following a little upper expansion. We must have used a lower bow that was not passive, for we produced labio-occlusion of $\overline{6|6}$. Finally we extracted $\frac{7|7}{7|7}$ (age 13.0).

Now at 20.11 years his lips are sealed at rest. He swallows with his lower lip a short way up his upper incisors. The models show very little change in position and relations of teeth

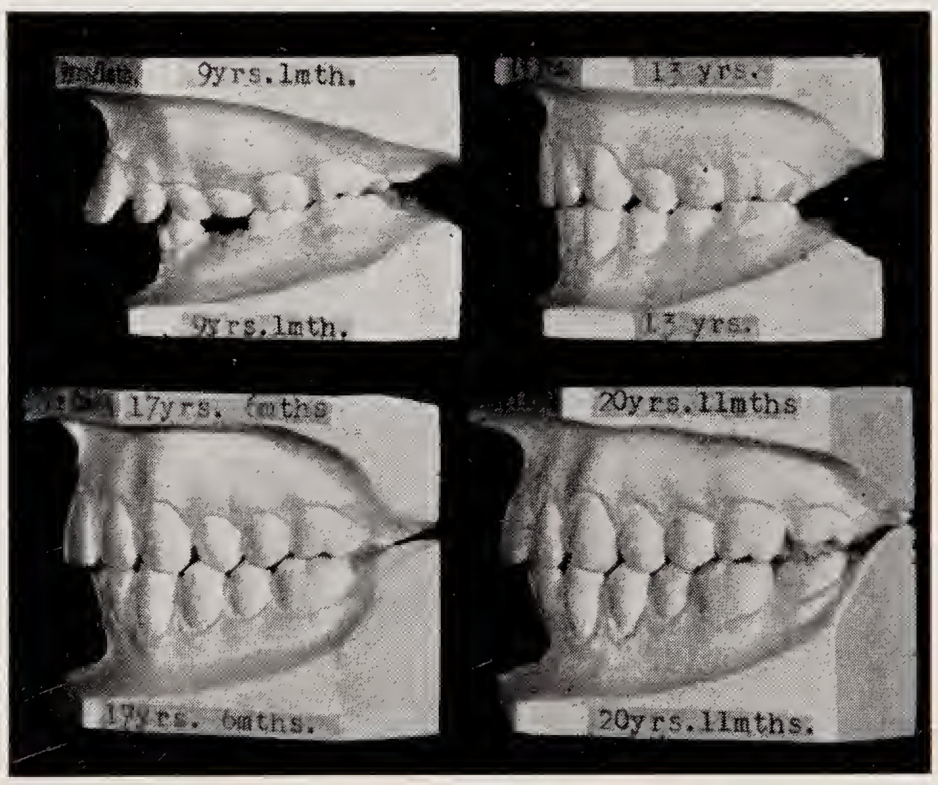
since treatment finished. I think he is one of those patients we all hope for whose treatment goes well with almost any form of appliance therapy.

His lateral radiograph is as one would expect.



Case 9 (*Fig.* 10).—My last Class II, Division 1 patient shows how a lip seal sometimes becomes established even with little treatment. His only treatment was the extraction of $\underline{4|3}$ (age 12.11) and a little alinement of his upper incisors in 1939 (age 13.4). In spite of a considerable number of extractions in both arches the incisor teeth have held remarkably to their relations (age 28.4).

A photograph of him as a boy showed him smiling, with his upper front teeth well to the fore. Now his lips are sealed at rest and during swallowing. This is quite a noticeable feature of his face. However, he still swallows with teeth apart and tongue brought forward, making contact with the lower lip. His lateral



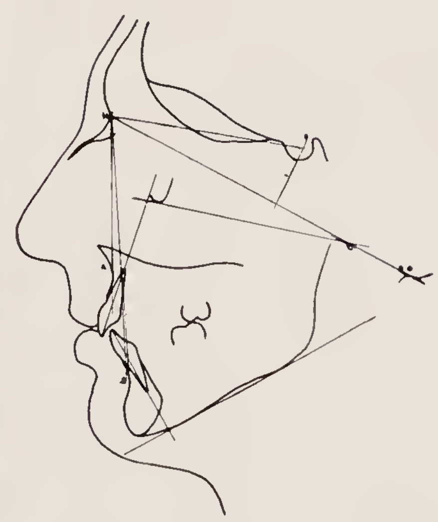
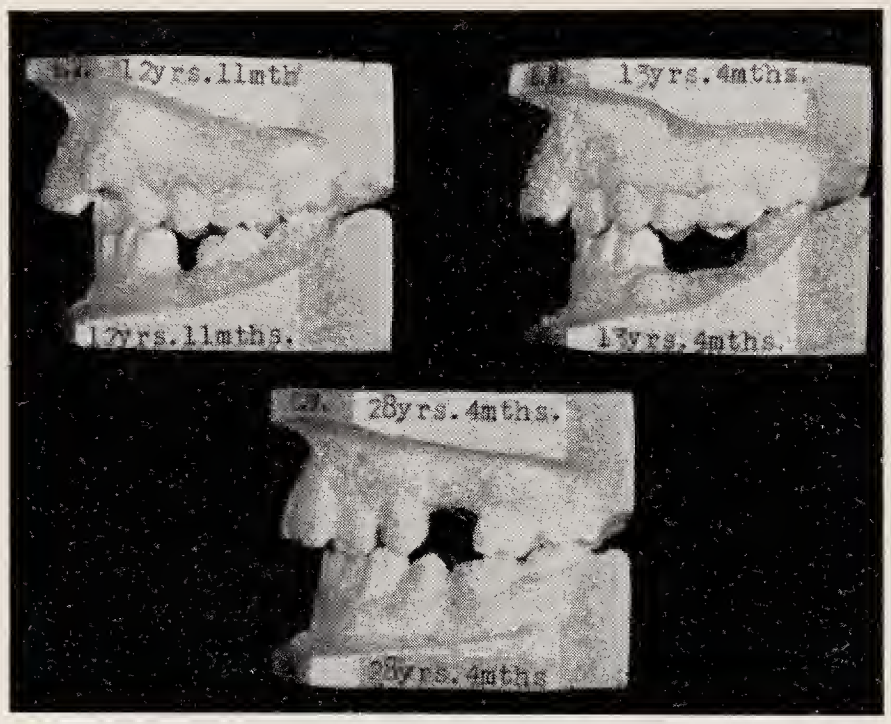


Fig. 9.—*Case* 8, treated by intermaxillary traction followed by extraction of $\frac{7|7}{7|7}$.

profile tracings are not remarkable except for perhaps a rather high Frankfort mandibular plane angle.

His electromyographic report says: "No outstanding aspects of this electromyograph.



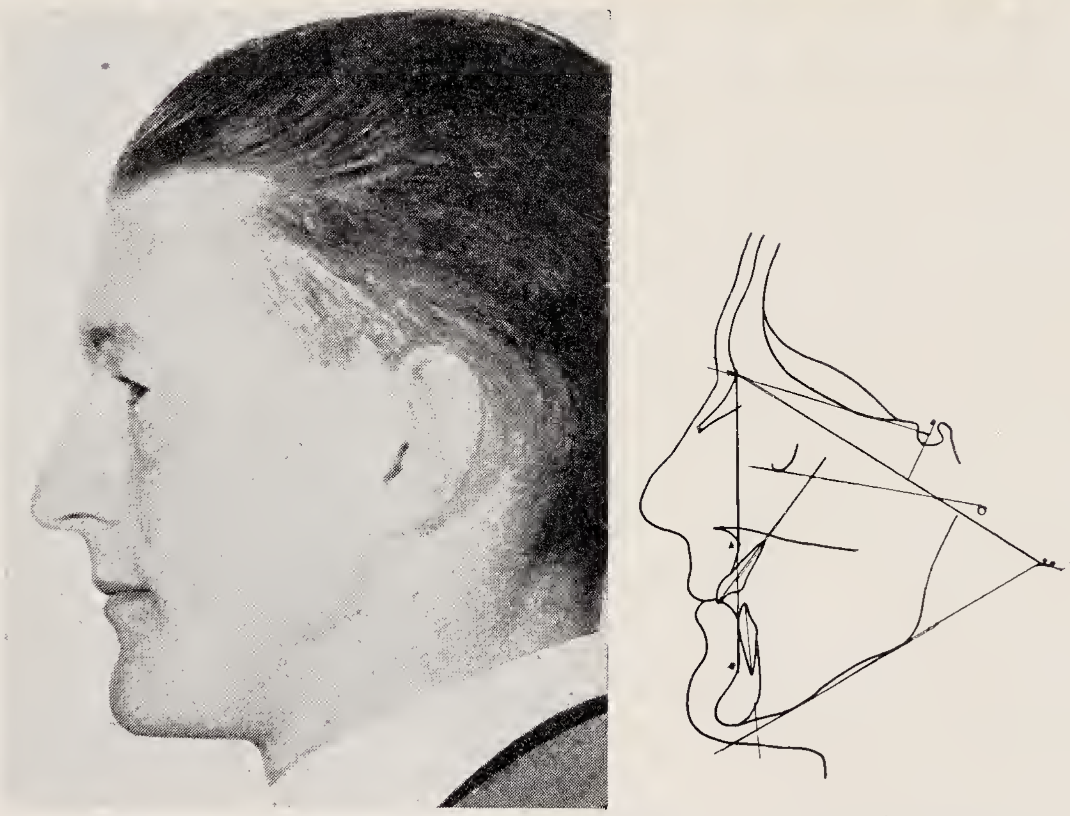


Fig. 10.—*Case* 9. No appliances; treated by extraction of $\underline{4|4}$.

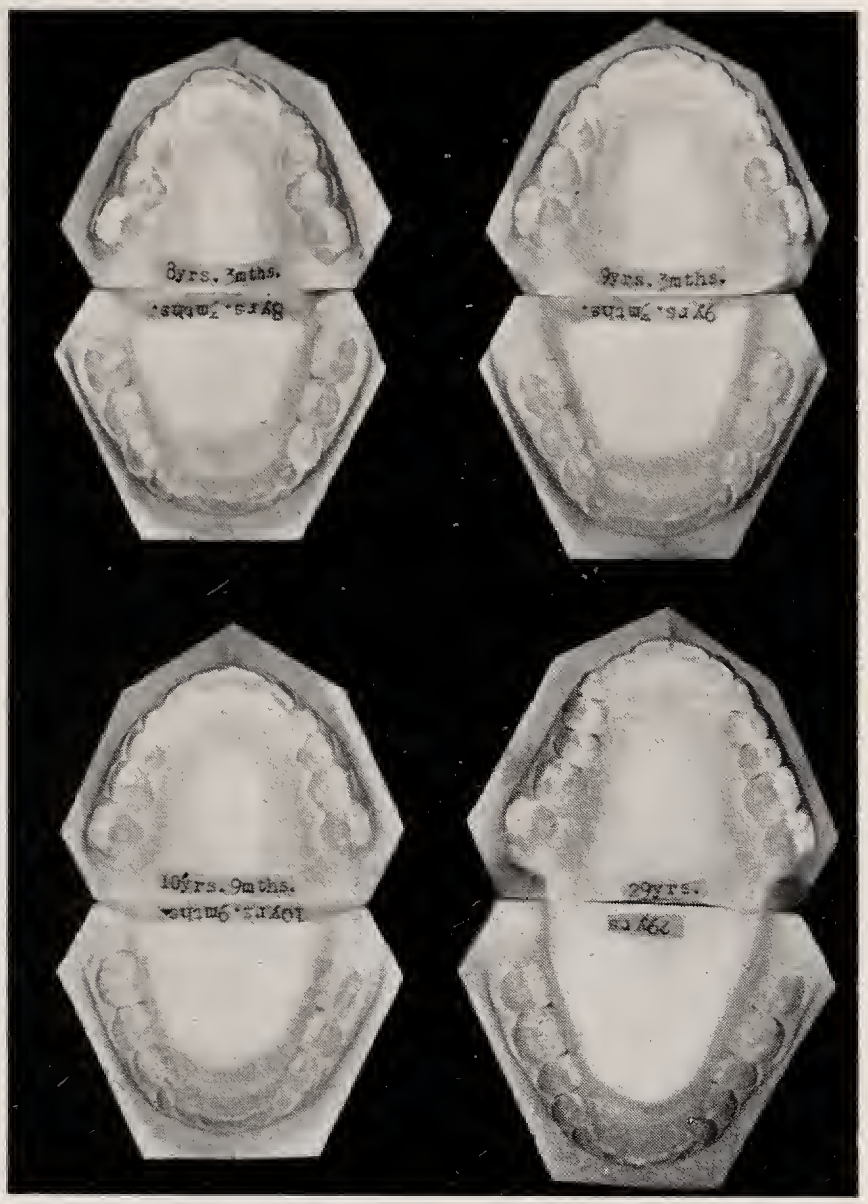
No well-defined masseteric contractions; which indicates a 'tooth apart' swallow. More than average lip activity."

Case 10 (*Fig.* 11).—My last case is from my early days in practice. I made notes that the patient who was 8 years 3 months old when I first saw her, was pale, quiet, and shy, but observant. Her mother had lingual occlusion of the upper molars and canines, but her incisors were in normal relations. Her sister had normal occlusion. I also noted the slight imbrication of lower incisors with an otherwise normal arch. Like her mother, she had a very narrow, high-vaulted palate. Except for $\underline{1|}$ all the upper teeth were in linguo-occlusion. I classified the case as Angle Class I, but I am sure that to-day I would have said there was a tendency to a skeletal III, and that I would have said that the mother was skeletal III also, although she also may have shown an Angle Class I malocclusion. Though of course in 1933 I did not look for such a thing, I am also certain that the child was one of those who swallow with the tongue placed ("thrust" is the wrong word) between the cheek teeth.

Treatment was simple and consisted in advancing the upper incisors over the bite and expanding the upper arch with expansion plates (age 9.3). Three appliances were required, with twenty-eight visits during active treatment. After this there were seven visits for observation (age 10.9). My last note is one year after my last models and reads "Premolars erupting well".

I was very happy to have the opportunity of seeing this patient again recently because, as far as I know, very little has been published about this type of case compared with Class II, Division 1 cases. The patient is now 29 years of age. $\overline{8|8}$ show disto-angular impaction. In spite of the skeletal III tendency, all the upper teeth occlude normally except $\underline{6|}$. In this area after the expansion there had been a gain of 7 mm. Since treatment ceased 6 mm. of this have been lost. There has been considerable diminution also (3–5 mm.) in the measurements between the first molars and the incisors in both arches.

It was difficult to get the patient to swallow naturally, but as far as I can tell she swallows with cheek teeth slightly apart and the tongue



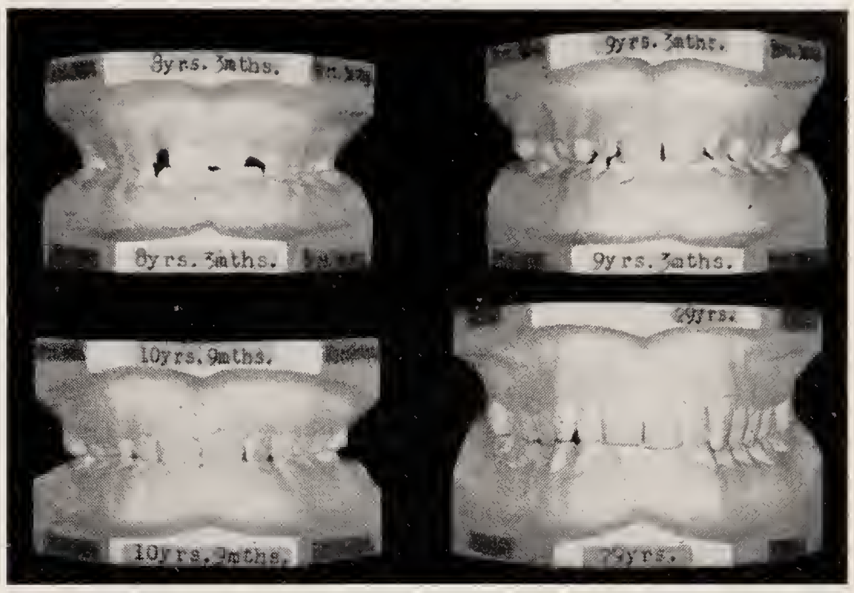


Fig. 11.—*Case* 10, treated by upper expansion and plate to push |1 over the bite.

placed rather forward between upper and lower premolar teeth. The lips of course are firmly sealed.

Before concluding, I would like to thank the patients, now adult, who returned for examination. In every case I was lucky, for they had all been keen and co-operative during treatment.

Acknowledgements.—My thanks are due to Mr. Bocquet Bull and Mr. Rix, under whom some of these cases were treated. I must also thank the Dental Council of Guy's Hospital Dental School for the facilities provided for my illustrations; Miss Whitely and Mrs. Pearson for their photography; Mr. W. Colwell for excellent work on models; Mrs. Rawlins for tracings; and of course Mr. Tulley for his electromyographic reports. Lastly, I must again thank Mr. Chapman for letting me show his case. Mr. Chapman's search for truth has been one of the foundations of this Society, and the fact that he was entirely agreeable to my showing his case is just one more example of the way we should all proceed.

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Mr. Norman Gray congratulated Mr. Pringle on his election as President of the Society and said that his Presidential Address would be of immense permanent value, as it contained carefully weighed evidence from Mr. Pringle's rich experience and drew attention to the focal point of good diagnosis.

The question of long-term end-results of orthodontic treatment was very important. The relating of oromuscular behaviour to the skeletal development of the jaws was one of the great key secrets to long-term success or failure. Adequate lip seal must always act as one of the main stabilizing factors, just as surely as inadequate sealing of the lips inevitably meant instability, relapse, and ultimate failure. Long-term results often depend on a thorough initial diagnosis; therefore very full case notes should be made, and, when they had been recorded with carefully articulated models and a detailed X-ray examination, they should be thoughtfully appraised and re-written, the malocclusion classified, and a report made on the X-ray findings. The final notes should include a written diagnosis and outline of treatment, together with the prognosis, largely based on the adequacy of the lips to retain the dental arch. He himself made a point of reading the X-ray report and the active treatment notes at nearly every visit.

Orthodontists should take a great interest in any deviation from normal breathing through clear nasal passages. Class II, Division 1 children often suffered from some nasal defect or had a persistent catarrhal condition with stuffy breathing. A large proportion of children under orthodontic treatment had bad respiratory habits completely unchecked. At his orthodontic clinic he had been able to obtain the help of physical training instructors from a training college, who gave the children exercises to encourage nasal breathing. They were also given lip and tongue exercises by being taught to repeat phrases such as "Peter Piper picked a peck of pickled peppers". The children were supervised, and thcy were marked for the successful performance of the exercises in their homes.

If he had had longer notice of the invitation to open the present discussion he could have collected and photographed a group of Class II, Division 1 cases that had remained in ideal occlusion over many years. He felt sure that every successful result would show not only an adequate cover of the upper incisors by the lower lip but also the establishment of good nasal respiration.

Miss L. M. Clinch congratulated the President on his very interesting address.

It would seem from the President's lecture that an abnormal swallow combined with a strong lip seal resulted in collapse of the lower incisors, whereas an abnormal swallow without a good lip seal resulted in collapse of the upper (but not the lower) incisors. In her experience the collapse of the lower incisors was very much the more common and was in fact one of the big problems in orthodontic treatment. It was very difficult to be sure that the lower incisors would be in good alinement ten years after all appliances had been removed, and cases which had good occlusion until 19 or 20 years of age showed some collapse of the incisors about that stage. Would the abnormal swallow not affect the occlusion sooner if it was solely responsible for this later collapse in untreated cases?

It was very interesting to see that the case shown by the President in which there had been no relapse at all, and in which the result had been excellent, was one of the two cases in which there had been no extractions. The relapse in the other cases might be partly due to the fact that the postnormal arch relationship had been treated by extractions in the upper arch and retraction of the upper incisors instead of by an attempt to correct the arch relationship.

Mr. J. H. Hovell said he thought the chief lesson to be learned from the President's address was that the most important thing in orthodontic treatment was the need for ultimate stability of the upper and lower incisor teeth, within muscle balance.

In the old days, when orthodontists did not know anything about skeletal pattern, they had put the teeth into correct relationship with the lips and had obtained good results, which did not relapse very much. He thought that they should return to observing the soft-tissue behaviour and should avoid the mechanistic approach to orthodontics which was likely to arise from too great a consideration of skeletal patterning factors, with attempts to produce ideal relationships often unattainable or unstable.

Mr. H. Chapman congratulated the President on the excellence of his slides and results, particularly his long-term results.

With regard to the imbrication of the lower incisors, one of the cases which he had shown in a recent address had normal occlusion with good upper and lower incisor alinement until the age of 15 or 16 years, and then developed imbrication of the lower incisors without having had any orthodontic treatment. It seemed to him, therefore, that it was a natural phenomenon.

When the premolars had erupted into a space which was too small for them, he thought that might have been at the expense of the lower incisors, in which greater crowding was shown.

In one of the cases shown at the age of 29 years there was a remarkable degree of lower lip covering the upper incisors. If that was one of the cases in which the alveolar process and the upper arch anteriorly appeared to be of unusual length, that might be part explanation.

In the cases shown by the President there seemed to be an unusually large number in which the arch was long as compared with the width.

Mr. C. F. Ballard congratulated the President on his address and referred to the question of relapse. He said that if a study of soft-tissue behaviour indicated what was going to be the stable end-result orthodontists should not regard a case as a failure if, in the end-result, the incisors were not in the position which the text-books stated to be the ideal occlusion. If, for instance, an orthodontist saw a case with an overjet of half an inch and a reduction by only half that amount was all that would remain stable, that case should be regarded as a satisfactorily treated case in that position. Both time and money would be saved if orthodontists attempted to achieve only that which would be a stable end-result whether or not that was a normal occlusion.

A number of questions were asked during the discussion by Messrs D. F. Glass, J. E. Phillips, J. H. Gardiner, P. J. Holloway, and E. K. Breakspear.

The President thanked all those members who had taken part in the discussion (which he had enjoyed) and said that he would take presidential licence and not answer them formally.

On the motion of *Mr. S. G. McCallin*, a vote of thanks was accorded to the President for his address, and the meeting then terminated.

oOo

THE PHYSIOLOGY OF MASTICATION*

By **D. J. ANDERSON,** Ph.D., M.Sc., B.D.S.
Physiological Laboratory, Guy's Hospital Medical School, London, S.E.1.

Mastication is the mixing of the food with the saliva and its reduction to a size and consistency suitable for swallowing. The role of the teeth in this sequence of events is to transmit to the material being chewed the forces exerted by the muscles of mastication. The hinge movements, the forward and lateral movements which are made possible by the structure of the condylar articulation, allow these forces to be deployed where necessary. Initially force is transmitted through the anterior teeth in cutting off the mouthful, later through the posterior teeth in grinding and crushing the food. The limits to the movements occurring during mastication are set partly by the soft tissues of the mouth and the structure of the condylar articulation, but also, when the teeth are close to centric occlusion, by the inclined planes of the tooth surfaces.

With specially chosen soft or semiliquid food it is possible to reduce the role of the masticatory machinery to that of a mixing apparatus, but even with the present-day diet some structures capable of transmitting force from the jaw muscles to the food are necessary either in the form of natural or artificial dentures. In the last analysis, therefore, mastication means the application of force and it seems logical when studying the physiology of mastication to give pride of place to an investigation of the forces involved.

Many people, starting with Johannes Alphonsus Borellus (1680), have measured the maximum biting force of which the masticatory apparatus is capable. Borellus employed the simple technique of hanging weights by a cord across the molar teeth. He calculated that the maximum power of the jaws was approximately 500 lb. Many investigators have devised more complex methods of measuring maximum biting power and it is appropriate to refer to a past president of this society, Sheldon Friel (1924), who measured maximum biting forces in children, and attempted to correlate these and other mouth forces with other measurements of developmental progress such as height, weight, and hand-grip force. With mastication, as with many other movements, the potential of the muscles greatly exceeds the actual forces employed in everyday activities, and these measurements of maximum biting power give little indication of masticatory forces. The difficulty so far has been to produce a measuring technique which allowed mastication to take place unhindered, and the technique which was reported in a previous paper (Anderson, 1953) is the first which allowed unhindered mastication with the natural dentition. I propose to give a brief outline of this method and also to indicate modifications which have been made since then.

The method depends on the use of the resistance wire strain gauge. This is a device which consists of a coil of resistance wire attached to a fairly rigid resin-impregnated paper backing. When the coil is stretched or compressed, the resistance changes and over a certain range resistance change and dimensional change are related in a linear fashion. The resistance change can be recorded with a simple Wheatstone bridge circuit and a suitable recording instrument such as a galvanometer or cathode-ray oscilloscope. If a strain gauge is firmly fixed to a structure being subjected to loads, then the resulting dimensional change in the structure being transmitted to the strain gauge will cause a resistance change which provides a highly sensitive index of the dimensional changes in the structure under load. In adapting this device to the measurement of masticatory loads the strain gauge is attached to a suitably

* Some of the observations reported in this paper form part of a thesis for the degree of Ph.D. at the University of London.

Given at the meeting held on February 14, 1955.

supported metal bar which can be reversibly distorted by masticatory loads. By the application of known loads to this metal bar outside the mouth it is possible to construct a calibration graph relating the applied loads to the resistance change on the Wheatstone

Fig. 1.—Strain gauge unit shown diagrammatically.

bridge circuit, as indicated in this case by the deflection of an oscilloscope beam. Then, observation of the deflections produced by forces inside the mouth allows the determination of these forces by reference to the calibration curve. The most important demand to be made of any apparatus constructed on these lines is that it shall be small enough to be accommodated either in a cavity in an existing natural tooth or in an artificial tooth. The apparatus must allow unhindered movements and occlusion, and must be capable of responding at the frequency of the masticatory movements.

Strain gauges of dimensions 2 mm. × 3 mm. have been made specially for this investigation at the National Physical Laboratory and the supported metal bar is constructed of silver steel in the form of an arch with a central platform. The strain gauge is firmly attached to the under-surface of the arch by means of phenol-formaldehyde resin. The whole structure, as shown in *Fig.* 1, has dimensions of about 5 mm. × 3 mm. × 3 mm. high. A suitable cavity is prepared in a live tooth and an inlay constructed in which an oblong vertical-sided cavity is cut to take the strain gauge unit. In addition the upper edges of the cavity in the inlay are cut back to form a ledge of about 1 mm. in depth and variable width. Where convenient, pits are sunk from this ledge into the substance of the inlay, and with the strain gauge unit in position a second wax pattern is prepared for an inlay to occupy the ledge and pits and cover the strain gauge unit with the exception of its central platform. When this inlay is cast, its under-surface is freed of contact with the gauge unit by grinding. It is a removable inlay placed in position after insertion of the gauge unit and held in position simply by its downward projection—sometimes a little zinc oxide paste was used to help its retention. Its function is to protect the gauge unit from the biting forces except in the central portion. The whole apparatus in situ is shown in *Fig.* 2. Leads from the strain gauge are made of fine copper wire covered with enamel and cotton impregnated with resin. The leads leave the strain gauge tooth through a convenient hole in the main inlay mesially or distally on the lingual side. They then pass along the lingual side of the jaw to leave the mouth through a suitable lower incisor interdental space. The leads are protected from engulfment during

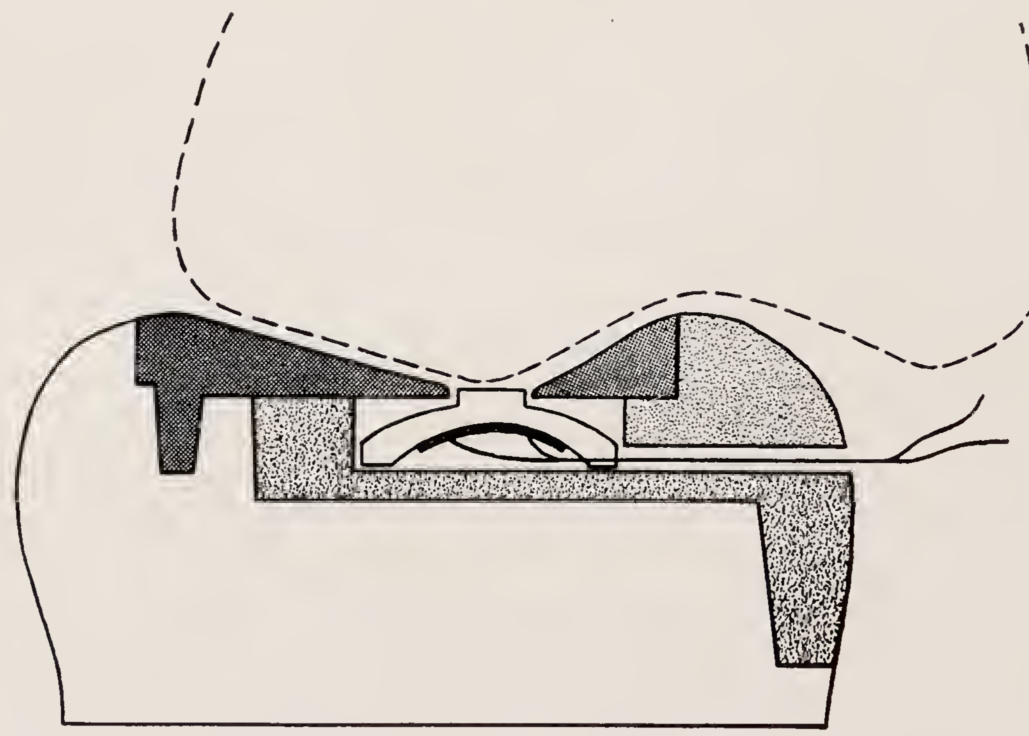

Fig. 2.—Diagram of the strain gauge unit in situ. The lightly shaded area represents the permanent inlay, the darkly shaded area represents the temporary covering inlay.

mastication by a very thin plastic plate which is applied to the lingual side of the lower arch.

This apparatus has been constructed for six subjects and at present results are available from four of these. The first experiments have been simply to study the loads obtained when chewing three different types of food. The first was a fairly hard biscuit of a texture similar to a ginger nut but not as hard. With this biscuit, movements of the jaws without

any force being applied are sufficient to bring about dissolution of the material in the saliva. Force is therefore not essential, although it is customary to use it rather than wait for the biscuit to break up in the saliva. With the other two materials, carrot and meat, solution

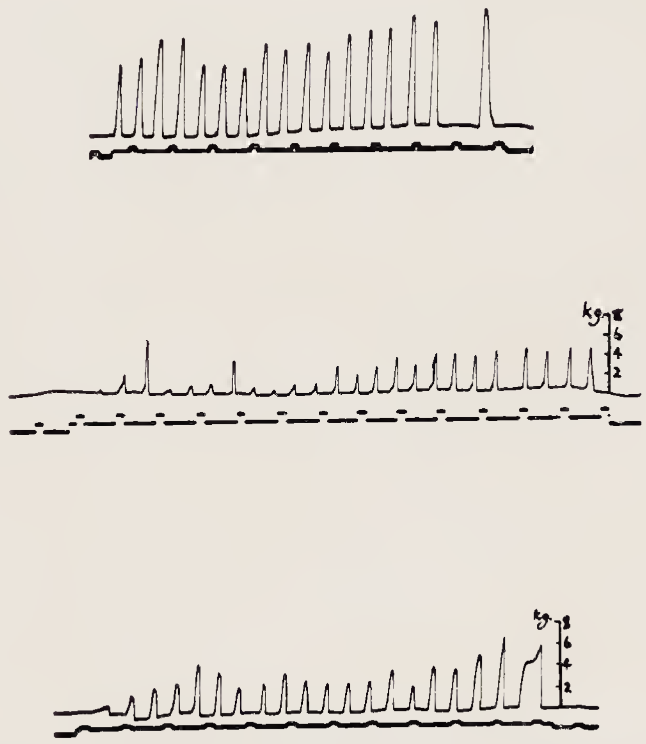

Fig. 3.—Oscilloscope records taken during chewing sequences. The upper tracing is the strain gauge response; the calibration scale has been inserted for convenience of reading. The lower tracing is deflected upwards at one-second intervals and is raised bodily for the duration of the chewing sequence.

in the saliva is a very small contribution to the preparation for swallowing, and force must be applied. It was hoped by using the same batch of biscuits throughout and relying on uniformity of carrot and meat to provide three test materials with which comparison could be made between the four subjects of the investigation. However, this was not to be, since it was found at an early stage that the carrot varied considerably in texture and we were forced to use different kinds of meat with considerable variations in tenderness.

Examination of individual records, examples of which are shown in *Fig.* 3, reveals certain characteristics. First the loads recorded towards the end of the sequences are in most cases greater than at the beginning, and in some the last one or two thrusts are larger than the rest, more prolonged and separated from the rest by more than the usual interval. There are several possible explanations of the increase in loads towards the end of the sequence. The most obvious is, of course, that the subject is increasing his muscular activity, but this is not the subjective impression, not that I attach a great deal of importance to subjective impressions. The second possible explanation is the one which seems more likely. The apparatus reeords only the vertical component of the total force applied. In the early stages when the piece of food is large, the application of force breaks the large piece into several small pieces which are driven laterally. This must mcan dissipation of the force laterally, with a consequent reduetion in the vertical component. When the material is reduced to smaller pieces less resistance is met by the jaws as they move together through the mass of food—pushing some of it latcrally, and the vertical component is therefore a bigger fraction of the total than before. The recorded loads never exceed 8–10 kg.

The second point to be observed in the tracings is the swallowing thrust. This is particularly well marked in two of the subjects, not so frequently or clearly in the third, and hardly noticeable in the fourth.

Measurements of loads recorded on a few square millimetres of gauge unit platform cannot give any direct indication of the loads on the whole tooth. It is a weakness in the method that it does not allow such direct measurements to be made, but such a weakness is unavoidable unless the recording device is arranged to record from the whole occlusal surface of the tooth. This would mean that the entire crown would be sacrificed and the application of a method requiring such a large part of the tooth would be restricted almost entirely to dead teeth. Since the recording device only samples the load from a small chosen area of the tooth any calculation of the total must be based on assumptions and therefore can never arrive at an indisputable answer. The assumptions which are made are first, that the distribution of load is uniform over the whole occlusal surface of a tooth, and second, that the surface which takes the load is the surface which is in contact with the opposing teeth in centric occlusion. Instead of calibrating the strain gauge by directly applying the loads to the platform,

the method is now altered so that the strain gauge unit is calibrated in a model of the tooth and the load is applied through a model of the opposing teeth, with opposing surfaces correctly articulated. Comparison of the two curves obtained by the direct and whole-tooth calibration showed, in one case for example, that whereas a load of 4 kg. applied directly to the strain gauge and taken in entirety by the strain gauge gives an oscilloscope deflection of 7 mm., the same load, when applied to the gauge unit in situ, and shared between the gauge platform and the other contact areas, gives a deflection of 3·6 mm. only. The use of the method of whole-tooth calibration gives a very close approximation to the actual loads taken by the tooth. The reason it is not claimed that the method gives the true loads on the tooth is because separation of the teeth by food must mean that the area bearing the thrust will now be slightly larger, since the intervening food will to some extent fill in the fissures and make them load-bearing areas. Unfortunately this method of approaching the true tooth loads was only developed at a late stage in the investigation when two of the subjects were no longer available. However, in the remaining two, by means of the double calibration, it was possible to relate the whole-tooth and direct calibrations by a factor which in the case of L. V. H. was 1·9 and D. J. A. was 2·8. Recalculation of the figures on this basis gave results which must be close to the truth in these subjects.

Table I.—Mean Total Whole-tooth Loads per Chewing Sequence

	Subject D. J. A. Load kg.	Subject D. J. A. σ (standard deviation)	Subject L. V. H. Load kg.	Subject L. V. H. σ (standard deviation)
Biscuit	138·1	± 31·9	142·2	± 19·8
Carrot	149·4	± 20·3	160·1	± 79·4
Meat	66·5	± 21·0	134·0	± 47·6

The results from the two subjects D. J. A. and L. V. H. have been presented in two ways: First the loads applied at each thrust have been added up and expressed as a whole-tooth load for every chewing sequence. This represents the total force applied to the food between the teeth concerned. It will be seen in the case of biscuit and carrot that these are not significantly different in the two subjects (*Tables I, II*). With meat, however, the total load applied by D. J. A. averaged only 66·5 kg. compared with 134·0 kg. by L. V. H. Since the loads vary so much during individual chewing sequences, a determination of the mean load per thrust would be of little value. I have therefore taken the largest thrust out of each sequence and calculated the mean for the series of twenty sequences in both subjects for the three foods. These results show that in L. V. H. the mean maximum does not vary significantly whatever the food. In D. J. A. the maxima are not significantly different with biscuit and carrot, but the meat value is significantly different from the others. With carrot D. J. A. and L. V. H. apply maximum loads which are not significantly different, but with biscuit and meat the values are different, D. J. A. applying a higher maximum on biscuit than L. V. H. and a lower maximum on meat than L. V. H.

Table II.—Mean Maximum Whole-tooth Loads from Twenty Sequences

	Subject D. J. A. Load kg.	Subject D. J. A. σ (standard deviation)	Subject L. V. H. Load kg.	Subject L. V. H. σ (standard deviation)
Biscuit	14·9	± 3·02	11·4	± 1·24
Carrot	13·7	± 1·60	12·0	± 3·01
Meat	7·2	± 1·27	11·6	± 2·58

These load patterns represent the end-result of the highly co-ordinated activity of the muscles of mastication, and in the few subjects examined so far seem to show individual characteristics. The co-ordination of these complicated movements provides an interesting physiological study. Since quite large forces are involved even in chewing ordinary materials, the movements are not executed without some danger to the soft tissues of the mouth. The problem is not simply one of keeping the cheeks and tongue out of the way —these structures have the perilous function to perform of keeping the occlusal surfaces of the teeth supplied with material as the jaws come together. The co-ordination of the very complicated movements of the jaws and associated soft parts depends on accurate information from the parts concerned. To take a simple example of a muscle movement,

such as flexion of a joint, its accurate and smooth execution requires a background of nerve impulses from receptors in the muscles which act on the joint, from receptors in the tendons of these muscles, and from the joint itself. Surface receptors may contribute if the movement results in a change of relationship between the limb and its tangible environment. These impulses pass to the higher centres in the brain and it is upon their constantly changing pattern that the precision of movement depends. So it is in the mouth; receptors in the masticatory muscles and their tendons, in the tongue and surrounding soft tissues, and in the joint must all contribute. In addition, however, there must be some means whereby the force of the masticatory movements is regulated, and it is certain that receptors around the teeth contribute towards this. Pfaffman (1939) using the cat and Ness (1954) using the rabbit have recorded impulses from the inferior dental nerve when pressure is applied to the teeth. It is not known whether these receptors play an important role in mastication, but in the records I have shown we have a picture of the results of masticatory movements, pictures characteristic of the individual and the food being chewed. By procedures such as selective anæsthesia a method is available for testing the importance of the contribution of the periodontal receptors to the masticatory picture while leaving the contribution of muscle and tendon receptors unaffected. So much for the purely physiological extension of this technique in the study of masticatory movement.

Like biting forces, the movements of mastication have been investigated by many workers, especially those concerned with the shape and disposition of artificial teeth. X-ray photography, cinefluorography, mechanical tracing devices, and various photographic techniques have been employed. As with masticatory forces so with movements, the difficulty has always been to find a method which does not interfere with the movements being studied. It seems to me that the most interesting part of the movement is when the teeth are in or near contact. Hildebrand (1931) has made one of the most comprehensive studies of the masticatory movements and concludes that there is some slight lateral movement at the beginning and end of the movement and that there is gliding of the teeth of the lower jaw against those of the upper in some cases. There is also gliding in a sagittal plane before the opposing teeth meet. Although Hildebrand does not say so, his results suggest that centric occlusion or something very close to it is reached at the termination of most chewing thrusts.

Jankelson, Hoffman, and Hendron (1953) also made studies of masticatory movements using cinefluorographic methods. He also records lateral movement with the teeth closely related, but does not consider the path of these small lateral movements to be determined by the occlusal planes of the teeth since he found actual contact between the teeth during chewing to be rare. Tooth-to-tooth contact was recorded by using subjects who had metal crowns on posterior teeth. Wires were attached to the upper and lower crowns and contact was recorded by a simple electrical circuit which operated an ink recorder on a moving paper. He shows records of one subject eating apple and in this contact is only achieved at the end of the sequence during swallowing.

Yurkstas and Emerson (1954) recently studied the problem of tooth contact during chewing in 12 patients with artificial dentures. They recorded from both sides of the mouth and found, rather surprisingly, that when the subjects chewed a bread and corned beef sandwich, all of them achieved contact on the working side for part of the sequence, some made contact at every thrust, others but rarely. On the balancing side, however, they record that almost all subjects showed contact at every thrust. In neither Jankelson's nor Yurkstas's investigations is any attempt made to differentiate between the contact which might be achieved in a balanced occlusion during lateral excursion and centric occlusal contact.

Picton and I have started an investigation into the question of tooth-to-tooth contact in centric occlusion during chewing. The first series in the study has been carried out on

myself. My strain gauge apparatus is in $\overline{|6}$. The $\overline{6|}$ tilts forwards owing to the failure of the $\overline{5|}$ to erupt. An occlusal filling has been removed from this and a removable inlay has been prepared for it, the occlusal surface of

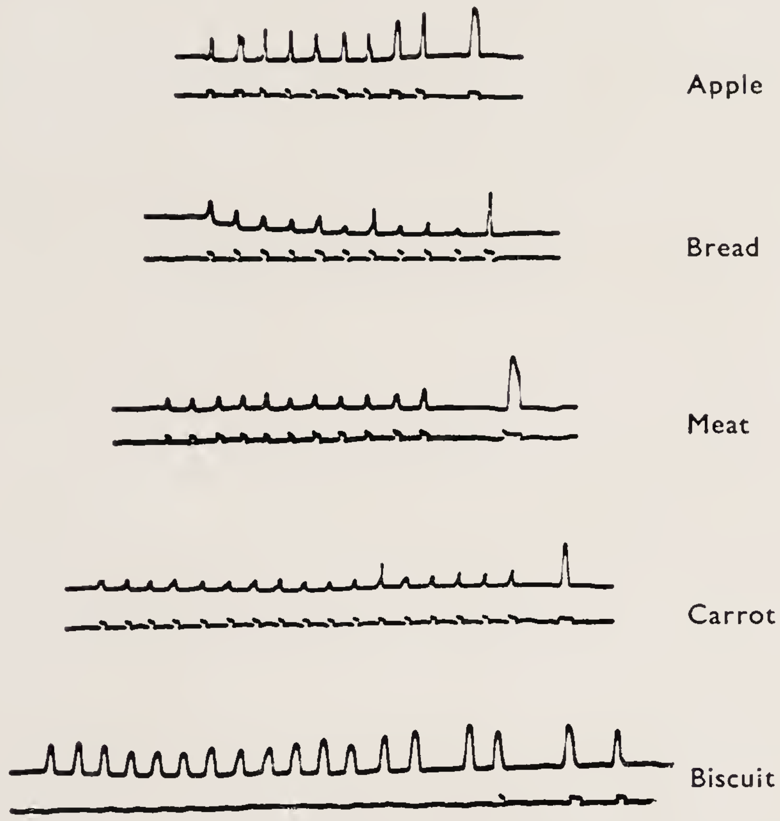

Fig. 4.—Oscilloscope records of strain gauge responses and tooth contact marking device during the mastication of five different materials. The upper tracing in every case is the strain gauge record. The lower tracing is deflected upwards when the teeth come into contact.

the inlay raised well above the occlusal surface of the tooth in the form of a narrow ridge about 1 mm. wide which runs antero-posteriorly and occludes with a three-quarter crown on the $\underline{5|}$. The $\overline{6|}$ inlay has a wire lead attached to it and is temporarily stuck in place with oxyphosphate cement for the duration of an experiment. A hole has been drilled in the $\underline{5|}$ three-quarter crown to accommodate a second lead during the experiment. The leads form part of a simple circuit supplied with 1·5 volts and connected to the lower beam of an oscilloscope, the strain gauge supplying the upper beam. The bite has been most carefully adjusted and the narrowness of the contact ensures that only slight movement out of centric occlusion laterally breaks the contact. Some records are shown in *Fig.* 4. The strain gauge records are shown on the upper tracing in each record and upward deflection of the lower beam indicates contact on the right side. It can be seen that with biscuit, contact is only achieved towards the end of the sequence, the last one or two thrusts, and the swallow. With all the other materials, however, contact is achieved at every thrust. I have tried to separate the teeth on the left while maintaining contact on the right and found that it is almost impossible. It therefore seems fair to assume that these records mean that centric occlusion is achieved.

In this account an attempt has been made to show how the application of modern techniques may help to establish fundamental facts of the processes of mastication. The volume of results from the strain gauge and tooth contact investigations is not yet sufficient to provide a firm basis for general conclusions.

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DISCUSSION

Mr. C. F. Ballard, in opening the discussion, said that, although it was usually regarded as the duty of the opener of a discussion to criticize the paper in order to stimulate discussion, it was very unwise for a clinician to attempt to do so in regard to the research work of a physiologist, anatomist, or biologist. Such research workers, however, must realize that much of their work was very narrow, and if it did not immediately fit in with a clinical observation they must not accuse the clinician of being wrong, particularly if other research supported the clinician. On the other hand, they should not give up their research if it appeared to have no immediate clinical application, as much and perhaps most of the really valuable work that had been done had been the result of following up a train of thought, perhaps even a subconscious train of thought.

Orthodontists were interested in oro-facial behaviour, and it was their duty to attempt to correlate the work of neurophysiologists, muscle physiologists, and perception physiologists, so that they had a more scientific understanding of their problem. He admitted that at the present stage he did not see the significance of Dr. Anderson's work on the pressures of mastication, except that it illustrated that there were similarities of pattern for each individual. He was sure that Mr. Tulley would be able to speak in a much more significant way than he himself could do in this respect.

Strain gauge pressure work had been going on in Boston for some years, and it had been well under way when he was there in 1950.

He proposed to sum up the question of pressures as he saw it clinically, for Dr. Anderson's consideration.

In spite of the work of Smith and Storey, who used enormous pressures, it was known that a pressure of 25 g. or less applied to a tooth would stimulate its movement and that this movement would continue, if there was no soft tissue or cuspal interference, until the spring was passive—in other words, at the end of that tooth movement the pressure was no more than a gramme or two. That was one of the reasons why orthodontists had to accept the statement that the dento-alveolar structures, whether normal or abnormal, were in balance in soft-tissue behaviour, except when there was obvious traumatic occlusion. It was because teeth were so easily stimulated to move, and because it was known from clinical observation that soft-tissue behaviour determined the position of the dental arches, that he could not accept Dr. Anderson's statement that centric occlusion was determined by the inclined planes of the tooth surfaces. He was not attributing this statement directly to Dr. Anderson; it was a generally accepted one which he thought was entirely wrong and it led to many misconceptions.

In his opinion, a good deal of recent research into the origin of motor activity supported the view that the rest position was endogenously determined and that the path of closure to centric occlusion was likewise endogenously determined. Weiss, as long ago as 1925, had stated that co-ordinated movements were the result of organized patterns of muscle combinations which produced the movements of the joint and that those organized patterns were relatively stable elements. Weiss had stated quite firmly that there was a hierarchical organization of these patterns of activity and that, though normally reinforced by proprioceptive reflexes, they took precedence over the latter in conflicting circumstances. He had not time to refer to the further research work which supported that view, but the clinical implications were that, if pressures of the order of a gramme or two could move teeth, not only should centric occlusion be a position in which the dental arches were in balance in soft-tissue behaviour but this position should be the same as that determined by the path of closure of the mandible. In other words, cuspal inclines only contributed to the alinement of the teeth during eruption. There were, however, cases in which there was traumatic occlusion as the result of cuspal interference in the path of closure; secondly, there were cases of resorption of roots of the teeth and thickening of the periodontal membrane when in fact they were not in traumatic occlusion; and, thirdly, there were the types of mandibular displacement which Grewcock and he had attempted to analyse clinically and physiologically in their Eastbourne paper.

The probable physiological mechanism of the last type of case must be understood before the other types of case can be analysed. Grewcock and he had postulated in their Eastbourne paper that there was a true endogenously determined path of closure for each individual, and that, if the cusps of two opposing teeth or several opposing teeth met at an angle which produced abnormal stresses in the receptor organs in the periodontal membrane, then in cases of mandibular deviation there was a reflex mechanism to take the mandible away from this abnormal contact relationship. Dr. Anderson had referred to the work of Pfaffman and Ness. In other words, there was within the individual the potentiality for developing a habit movement as a protective mechanism which superseded the endogenous movement. It was well known in physiology that such habit movements needed continual afferent stimuli for their maintenance, and Grewcock and he had pointed out that, clinically, if the opposing cuspal inclines which produced the afferent stimuli were removed the individual reverted within a few hours to the normal path of closure, forgetting the habit movement. If cuspal contact was made, it was probably an abnormal one in the majority of masticatory movements. In this connexion he would like to ask Dr. Anderson whether he was quite certain that in some of his recordings his strain gauge was not high on the bite.

Traumatic occlusion cases, therefore, were those in which, for some reason or other, there was not this protective reflex activity, and in which the teeth could not move as the result of these occlusal stresses into a new position of balance. In other words, the position of these traumatized teeth at centric occlusion was not the same as the position within the soft-tissue behaviour of lips, cheeks, and tongue. They were jiggled between the two.

The cause of this traumatic condition must be the result of a sum total of forces rather than a maximum force which Dr. Anderson had been measuring, these forces being applied in an abnormal direction. It seemed to him that if Dr. Anderson could in some way or other measure the sum of these forces over any period, say twenty-four hours, it would enable these pathological conditions to be understood more fully.

There was another type of trauma which came into the same category, being produced entirely by soft-tissue activity. It was not at all uncommon to find that, in cases of very vigorous tongue thrusting behaviour, the roots of the upper incisor teeth were resorbed and the periodontal membrane was thickened. There was an open bite because of this tongue-thrusting behaviour, and it therefore seemed to him that the only possible explanation was that the sum total of the forces applied by the tongue, and by the lips to resist the tongue thrust, were such that they stimulated the activity which produced the thickening of the periodontal membrane and resorption of the apices of the teeth. The teeth must be in equilibrium because they did not move.

Mr. Ballard hoped that Mr. Anderson would forgive the apparent irrelevance of some of what he had said, but it did appear to come within the scope of the title of the paper—"The Physiology of Mastication".

Mr. W. J. Tulley said he thought that a great deal of important information could be obtained by combining Dr. Anderson's studies with the electromyographic analysis of the chewing pattern. He realized that Dr. Anderson had the problem of finding suitable material, as inlays had to be inserted to carry the strain gauges.

In the studies of chewing movements that he had made with the electromyograph taking records from the masseter and temporalis, it had been found that there was not a great deal of difference in action potentials in the chewing of different foodstuffs. There was, however, considerable individual variation of general pattern and he hoped to be able to relate these patterns to different types of occlusion. He would like to ask Dr. Anderson whether he had examined the total force which his subjects could exert per square millimetre when their teeth were in centric occlusion.

Mr. R. D. Emslie said he had heard the suggestion made that a "Journal of Traumatic Occlusion" should be started, as such a journal could publish a great many theories and present a great many facts without any proof whatsoever. Having heard Dr. Anderson's paper, he was afraid that this journal, if started, would probably have a very short life.

Mr. A. W. Eastwood said it had occurred to him that the chewing habits of the individual concerned might have some effect in Dr. Anderson's experiments. He himself was supposed to have a normal occlusion and his bite was mostly well balanced, but if he was eating a tough piece of meat he chewed it on the left side, whereas when he was eating something soft he chewed it on both sides. As far as the interdigitation was concerned, it conformed completely to Angle's Class I.

Mr. L. H. Schuler asked whether Dr. Anderson proposed later on to make his masticatory experiments on orthodontic cases. He thought that, if so, Dr. Anderson might first take measurements of a number of normal cases, say from the age of 7 to 15 years, and then take measurements of other cases requiring orthodontic treatment, to see whether these, and cases with various abnormal swallowing actions, were unable to exert similar pressures on the bite gauge and whether after treatment, they were able to exert different pressures; in other words, whether the ability to masticate improved after orthodontic treatment.

The President asked whether Dr. Anderson could say what was the Angle classification in each of his cases.

Dr. D. J. Anderson, in replying to the discussion, said that the clinical application had not been his first object when he started his work. He took his stand on the statement that, since mastication meant the application of force, it seemed logical, when studying the physiology of mastication, to give pride of place to an investigation of the forces involved.

In reply to Mr. Ballard, he would say that the strain gauges had not been high on the bite. He had only the subjects' impressions on that point, but he thought that was a fair method of assessing the correct state of affairs.

He did not understand all that Mr. Ballard had said about traumatic occlusion. He did not know whether the teeth came into contact during chewing. He knew that in his own mouth the $\overline{6|}$ and the $\underline{|5}$ came into contact during chewing, but he could not say anything definitely about the other teeth in his mouth, though he could hazard a guess. He could not say anything about other people yet, and, as far as he knew, there were not many people who could say much more than that. He would have thought that it was essential to find out whether the teeth came into contact or not during chewing. If they did come into contact and if there was lateral movement before or after contact, it seemed to him that it was likely (he proposed to investigate this) that the path of the lateral movement might be determined by the shape of the cusps of the teeth. That could be discovered, he thought, by gradually making the very narrow contact in the lower arch much wider and seeing whether the duration of the contact indicated by the width and the elevation of the base line increased or not. If it did increase, one could assume that, by providing a larger surface of contact on the lower marker, the teeth were in fact gliding surface to surface during the initial or the last part of the movement, whichever it happened to be.

With regard to Mr. Tulley's question, he had not determined the maximum force. He had obtained his gauges so far free of cost, and he had therefore been a little careful of them. He had always wanted to get results with the food that was used at the time, and he had therefore been very cagey about deciding the limits of the experiment. However, he was now making his own gauges, so he might be able to be more liberal with them.

As far as applying his work to orthodontic cases was concerned, his best source of subjects was at the moment dental students doing a physiology course, and they ranged from 18 to 21 or thereabouts. He could not say whether they would become orthodontic cases or not. He always had models of the subjects. He did not think there was much prospect of applying his work as it stood to anyone except those people who were most readily available, but certainly information could be obtained about their orthodontic state.

With regard to Mr. Eastwood's remarks, unfortunately the subject was limited to chewing on one side, the side where the strain gauge was.

Finally, with regard to Mr. Pringle's question on the orthodontic classification of his cases. As far as he knew, his own classification was Class I and he thought the other subject's also was Class I.

oOo

ANGLE'S CLASS II, DIV. 1 AND CLASS II, DIV. 2 IN IDENTICAL TWINS

By **H. L. LEECH**, B.D.S., F.D.S., Dip. Orth.

It is generally accepted that factors which are genetically determined play a major role in growth and development, which includes the development of the facial bones and the occlusion of the teeth, normal and abnormal.

To quote Professor Anders Lundstrom (1947–8), "... the causes of malocclusions seem to a high degree to be hereditary in nature". "It is presupposed that the differences between identical twins, who have the same genetic constitution, are caused only by environment, while corresponding differences between fraternal twins depend on hereditary as well as environmental factors." With these thoughts in mind I present to you the following case histories of a pair of identical twins.

Fig. 1.—Photographs of the twins C. and M., showing the striking similarity of appearance.

CASE REPORTS

On presentation, C. and M., girls aged 13 years, showed a striking similarity of appearance, including such special features as the shape of the ear, the colour and texture of the hair, colour and markings of the iris, shape of nose and chin, shape of hands and nails, etc. (*Fig.* 1).

Although this similarity applied to the morphology of the corresponding teeth themselves, the occlusions of these teeth were remarkably different, C. possessing a marked Angle's Class II, Div. 1 (*Fig.* 2), and M. a marked Angle's Class II, Div. 2, malocclusion (*Fig.* 3).

Further evidence that they were indeed identical or monozygous was sought, and was confirmed from a history of a common placenta and from blood-tests of all the family for genotyping. Nine different blood groups were examined and it was found that those of the twins were identical. It was assessed that the odds that these twins were identical were 200 to 1.

Family History.—There was no other history of twinning and the parents were not related. The other child, a boy aged 16 years, was quite different in appearance, with a Class I malocclusion with crowding.

Individual Histories.—

Birth Weight: C., 6 lb. M., 5 lb. M. was first born by 10 minutes.

Feeding: Both mainly bottle fed.

Illnesses: Usual childhood illnesses. Both had tonsils and adenoids removed at $3\frac{1}{4}$ years.

Habits: Nil. No history of thumb-sucking in either child.

Walking and Talking: Both late.

Eruption and Shedding of Deciduous Teeth: Both normal.

Eruption Times of Permanent Teeth: Both normal.

Injuries to Teeth: None in either.

Present Condition.—

C., Class II, Div. 1. M., Class II, Div. 2.

Height: C., 5 ft., $2\frac{3}{4}$ in. M., 5 ft., $1\frac{3}{4}$ in.

Weight: C., 7 st. 11 lb. M., 7 st.

Dexterity: C., Right handed. M., Left handed—hrowing (right handed—writing).

Sight: Both myopie to a similar degree.

Caries Incidence Rate: Both low.

Periodontal Condition: Both good.

Skeletal Morphology: *Fig.* 4.

Given at the meeting held on February 14, 1955.

Both are Skeletal Class II with square-angled mandibles. The typical incisor relationships show the proclination of the upper incisors with increased overjet and overbite in the one, and the double retroclination with increased overbite in the other.

The composite tracing shows the close similarity of the skeletal patterns apart from their incisor relationships. The superimposition was both on the Bolton planes with registration points, and the S-N planes in the same composite.

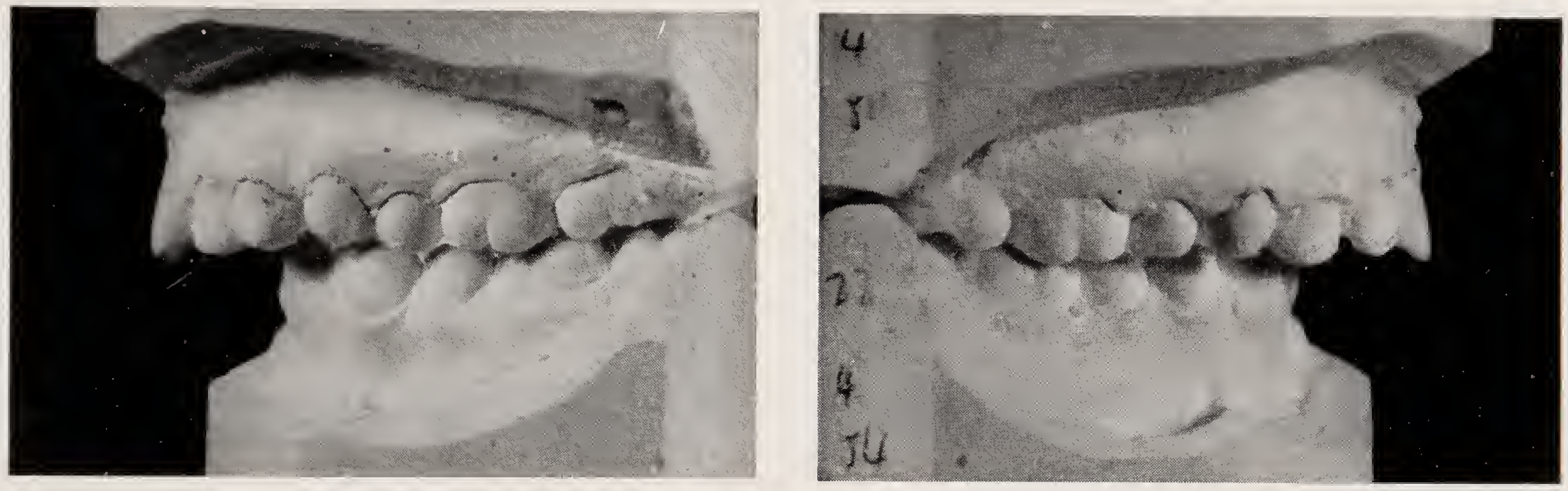

Fig. 2.—Showing the Angle Class II, Div. 1 malocclusion in the case of C.

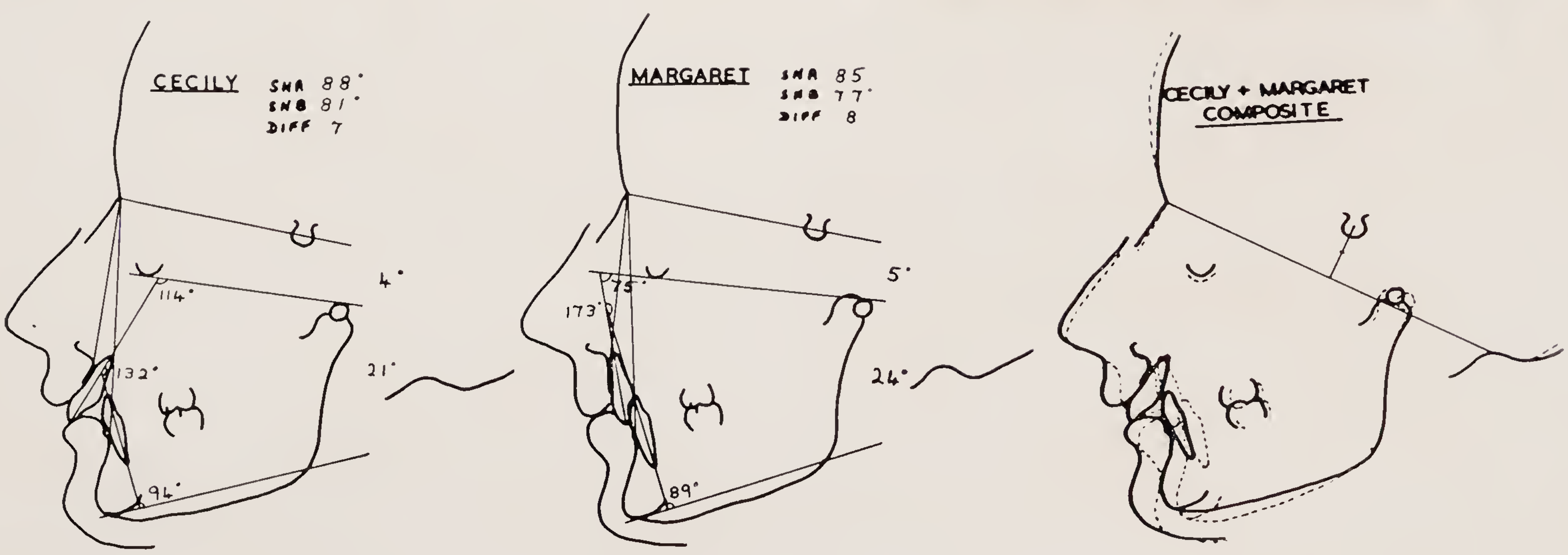

Fig. 4.—A comparison of the skeletal patterns.

Freeway Space: C., 6 mm. M., 3 mm.

Path of Closure (*Fig.* 5): C., Upwards and backwards. M., Directly upwards.

An interesting sideline is that in C.'s case two radiographs were taken with the object of securing the physiological rest position of the mandible; one with the incompetent lips at rest, and the other with them together. In the latter case, the mandible was postured forward subconsciously into a false resting position, as demonstrated by Ballard (1951). This may explain the

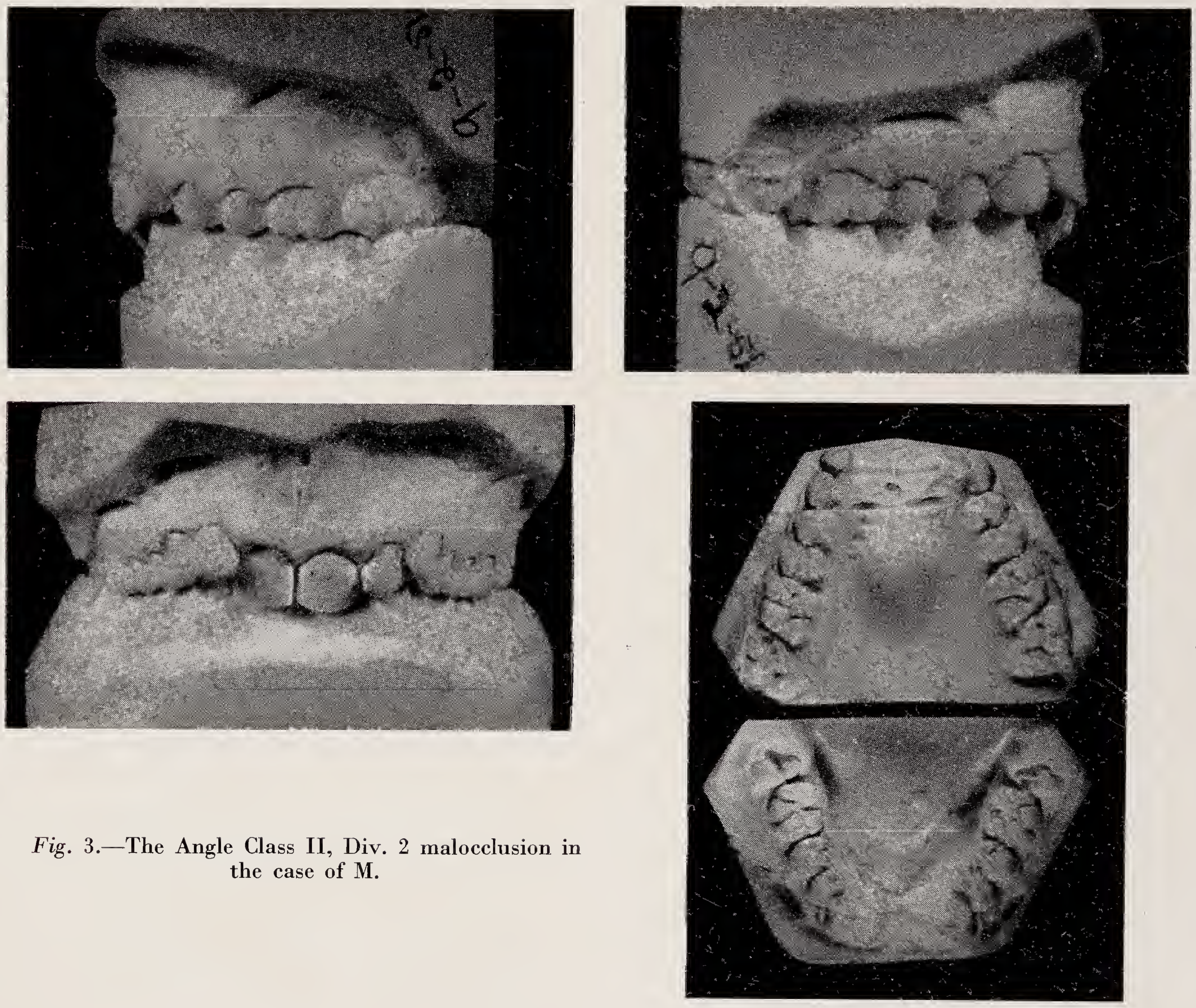

Fig. 3.—The Angle Class II, Div. 2 malocclusion in the case of M.

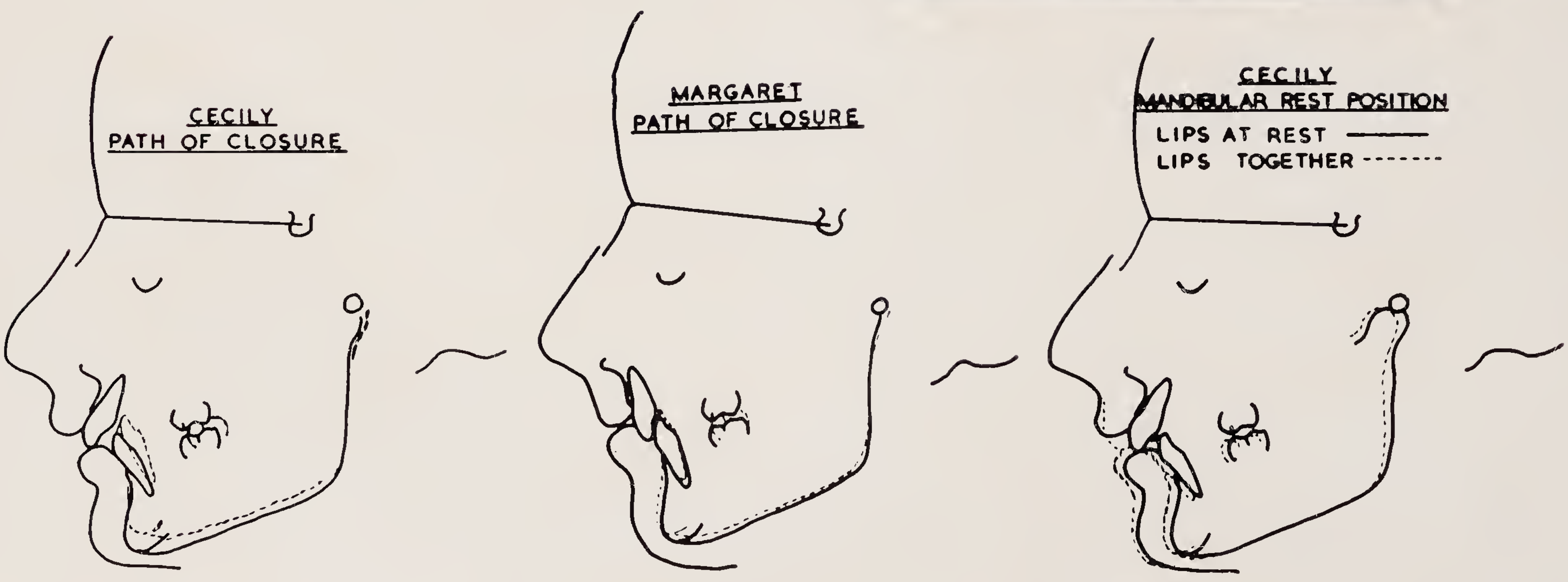

Fig. 5.—A comparison of the paths of closure.

downward and forward resting position of the condyle on the eminencia articularis in Class II cases as shown by Ricketts (1952).

Occlusal Patterns: These are shown very well from the study models.

Resting Muscle Patterns (*Fig.* 6).—The rest position of the lips is fairly similar in both cases, with slight incompetence in the case of C. There is a tendency for

Fig. 6.—Showing the position of the lips at rest.

Fig. 7.—Showing the position of the lips during swallowing.

the upper incisors to rest just over the lower lip in the Div. 1 case, and just behind in the Div. 2.

Muscle Behaviour Patterns (*Fig.* 7).—C., the Div. 1 girl, had an atypical swallow with the buccal teeth apart a tongue thrust between the upper and lower incisors, and contraction of the lower lip between the upper and lower incisors.

M., the Div. 2 girl, contracted the lips on swallowing, but with the lower lip against both upper and lower incisors. The buccal teeth were together and there was no tongue thrust.

An electromyographic analysis with two-channel electrodes showed contraction impulses from the lips in both cases. Contraction impulses from the temporalis and masseter muscles, however, were apparent *only* in the Div. 2 case.

Comment.—This case supports the view that skeletal and muscle morphology is genetically determined. The cause of the different types of malocclusion seems to point to the different muscle behaviour patterns.

I have discussed the case with an eminent geneticist, who is of the opinion that muscle behaviour may be only in part genetically determined.

He quotes the incidence of club-foot when occurring in twins. The ratio of it occurring in both twins is 1 in 50 in fraternal, and 1 in 4 in identical, i.e., it is very much more likely to occur in both twins when they are identical but not in every case.

May I close by saying that I would be most unwise to attempt to prove or disprove established concepts from one single case, and I present this short paper to you in the hope that it will stir your thoughts and maybe bring similar cases to light.

I would like to thank Mr. Hovell, the Director of the Orthodontic Department of the

Royal Dental Hospital, for permission to publish this paper, and Mr. Walther, Reader in Orthodontics, for his help. My thanks are also due to the Photographic, X-ray, and Pathological Departments. I am also grateful to Dr. J. N. Marshall Chalmers, of St. George's Hospital, and Dr. R. R. Race, of the Lister Institute, for the blood group genotyping.

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DISCUSSION

Mr. R. E. Rix asked Mr. Leech whether there was any difference in the histories of the twins as far as upper respiratory infection was concerned subsequent to the removal of the tonsils and adenoids. There did not seem to be a gross difference in the fundamental behaviour of the musculature in swallowing, but for the accident of the lower lip being caught beneath the upper front teeth, which were so very much proclined in C.

Mr. C. F. Ballard said he thought that in the film which Mr. Leech had shown there was very little evidence of a tongue thrust in either case. In the Class II, Div. 1 case the patient was constantly swallowing and there was only sufficient tucking in of the lower lip to produce an anterior oral seal with the increased overbite.

Occasionally one saw an individual who had the typical morphology of a Class II, Div. 2 case, but by mere chance, as it appeared, one central incisor was proclined, resting on the lower lip, and the other central incisor was retroclined, resting inside the lower lip, and the lateral radiograph showed a surprising difference in the position of the apices. In the case of the retroclined incisor the apex was labially placed, whereas in the case of the proclined incisor the apex was lingually placed. It seemed that the two cases which Mr. Leech had shown could together represent that type of case.

The President asked whether there was any difference in the width of the upper dental areh in the two cases which Mr. Leech had shown.

Mr. H. L. Leech, in replying to the discussion, said that the histories of respiratory infection after the removal of tonsils and adenoids were very similar in the two cases. There was no definite history that one was different from the other.

It might be a pure accident which determined whether the upper incisors erupted inside the action of the lower lip or outside the action of the lower lip, but he felt there was very much more to it than that.

In the Class II, Div. 1 case that he had shown there was a tongue thrust, but he thought that the increased incisor overjet was due as much to the contraetion of the lower lip under the upper incisors as to the tongue thrust.

The models of the two cases were very nearly interchangeable. A surprising point was that it was the Class II, Div. 1 case which had the wider arch, but it was only slightly wider.

ORTHODONTICS IN THE HOSPITAL SERVICE

By **J. D. HOOPER,** L.D.S. R.C.S., D.Orth.

In 1950 the South-West Metropolitan Regional Hospital Board advertised for a Consultant Orthodontist to be appointed to the Bournemouth and East Dorset Group of Hospitals. This was the first time that a Regional Hospital Board had proposed to add an orthodontist to its Consultant Staff. As the author has held this appointment for $4\frac{1}{2}$ years it was thought that an account of the experience thus gained in this hitherto unexplored field of orthodontics would be of some interest to this Society.

It is proposed to deal with the subject under three headings:—

1. A short discussion on the place of Orthodontics in the Health Service generally and with particular reference to the Hospital Service.
2. An account of the events leading up to the appointment of an Orthodontist to the Bournemouth and East Dorset Group and a report of the results so far achieved.
3. A few illustrations of cases to show the type of work undertaken.

ORTHODONTICS IN THE HEALTH SERVICE

To deal with this subject logically one should begin at the beginning and decide first whether orthodontics should be part of the Health Service at all. To put it quite bluntly, is orthodontics merely beauty treatment and if so should the State be expected to pay for it? This is obviously a very uninformed view but it is a charge which might well be levelled at orthodontics and for which we as orthodontists should have a convincing answer. I would concede that a proportion of orthodontics is, to the patient, beauty treatment. Most of us would agree that if teeth were invisible our intake of patients would probably fall considerably. However, I do not think that one should be in any way ashamed of carrying out treatment the purpose of which is to some extent the improvement of our patients' appearance—rather the reverse. We all know what an amazing change in the appearance of a patient can be brought about by the correction of some of the more severe mal-occlusions. It is quite likely that in such cases the benefit to the patient goes much further than the mere satisfaction of his personal vanity. The impact of that individual on society is altered in a way greatly to his advantage and his subsequent career and his usefulness to society greatly expanded thereby.

But there is much more to orthodontics than the improvement of the patients' appearance. The real answer to this question is quite emphatically that if dentistry is to be a charge on the State then orthodontics must also be. If the State is prepared to pay for the treatment of caries and periodontal disease it must also be prepared to pay for the treatment and prevention of mal-occlusion, since mal-occlusion is always a considerable factor in the production of these conditions and may be a direct exciting cause.

Furthermore, I would say that orthodontics at its best comprises the entire supervision of the dental development of the child and that only the orthodontically trained person is really equipped to carry out this supervision. An eminent American orthodontist during his recent visit over here impressed me by saying that in his view all children were orthodontic patients and should be referred from the orthodontist to the general practitioner and not the other way round. I do not think he meant this to be taken quite literally but I fully appreciated his trend of thought.

It is also relevant to point out that the National Health Service is not called the National Disease Service, and if its object is actively to promote health rather than passively to repair the effects of disease then orthodontics is fully entitled to its place in the organization.

The more difficult question to answer, however, is how orthodontics is to be brought to

Given at the meeting held on March 14, 1955.

the masses of children who really need it. There are three possible channels: namely, the School Dental Service, the General Dental Service, and the Hospital Service. In fact I think each of the three Services has a part to play in the provision of orthodontic treatment. This subject has been reported on at length by the British Dental Association's Committee on Orthodontics and I have nothing new to add to their findings. I agree broadly with the recommendations of this Committee, which were, briefly, that Regional Hospital Boards should appoint Consultants who would advise General Practitioners and School Dental Surgeons on the treatment of their cases and also run clinics to which the more difficult cases could be referred.

Although I am sure that this is the arrangement we should work towards, I have to report that in my experiences as a Hospital Consultant in Orthodontics there are certain practical difficulties. The fact is that a high proportion, indeed probably the majority, of dental practitioners do not like carrying out orthodontic treatment and are only too glad to refer their patients to a consultant for treatment rather than for advice. There seem to be certain reasons for this aversion to orthodontics. Some men have told me that they know nothing about orthodontics and do not feel capable of carrying out any but the most elementary procedures. Others say that they do not really enjoy treating children. The largest group, however, say that they would like to do more orthodontics if they knew more about it, but are not keen to carry out treatment under the Dental Estimates Board. They find it difficult, I think, to carry out a line of treatment which will satisfy the patient and be approved by the Board. They are irritated by the amount of correspondence which is involved, and feel that their clinical freedom is infringed when the Board fails to approve or asks some explanation of their line of treatment. It is not my place to discuss the rights or wrongs of this attitude, but there is no doubt that it exists, and in my view it constitutes a major obstacle to the working of the scheme recommended by the British Dental Association's Committee.

It seems to me that if this scheme is to work two major changes will be necessary. The first is an improvement in the arrangements for carrying out orthodontic treatment under the Dental Estimates Board, which will result in a corresponding improvement in the relationship between the practitioner and the Board. The second change is an alteration in the curriculum of the qualifying examinations which will permit more time being spent by undergraduate students on orthodontics. If this latter change is considered impossible then as an alternative some encouragement should be given to general practitioners to take post-graduate courses in orthodontics. Having been for many years on the teaching staff of the Royal Dental Hospital I have been rather dismayed to find how little practical knowledge in orthodontics has been absorbed by the average student.

At this point I would like to mention that each winter since I came to Bournemouth I have been requested to give a course of lectures on orthodontics for the general practitioner. This request has been duly complied with and the courses have been extremely well attended. The first year there were no less than 26 applications and the course had to be given twice. I think this indicates that a considerable interest in orthodontics exists, and it is an interest which I consider it part of my duties to foster. The result of these courses has been that the number of cases being referred for advice rather than for treatment has increased. The proportion remains rather low, however, and one has the impression that the men who are keen enough to attend a course are the ones who were already doing a fair amount of orthodontics in their practices.

A final point I should like to make on this subject is that cases treated by a general practitioner after receiving advice from a specialist seem to take longer than they should. There are many obvious reasons for this, not least, of course, the possibility that the specialist may not have been entirely infallible in his opinion. But also I think the general practitioner of necessity lacks experience in the hundred and one small time-saving

procedures that are or become second nature to the specialist and which it is almost impossible for him to impart. This lengthening of the treatment time raises the question of whether it is in fact economically advantageous for orthodontics to be carried out by the general practitioner following the advice of the specialist. I do not think that at the present time sufficient experience has been gained to answer this question, but in any case it is a somewhat academic one since it is most unlikely that there will ever be sufficient specialists to carry out all the orthodontic treatment required.

THE ORTHODONTIC CLINIC AT BOURNEMOUTH

The following is an account of how the Orthodontic Clinic at Bournemouth came into being. It is hoped that the recording of these facts may be of some assistance to those in other areas who may be considering the institution of a similar scheme.

To put the matter into perspective it is necessary to go back to the year 1921. In that year a group of Bournemouth dental surgeons formed a Voluntary Dental Clinic. The dental surgeons gave their services free and the patients, as in voluntary hospitals, contributed according to their means. To begin with the Clinic was separate from the local voluntary hospital, but in 1926 it was moved into a building adjoining the Royal Victoria Hospital and became a department of that hospital. In 1932 the private block of the hospital was built and a new Dental Department was included in it. The Department consisted of Surgery, Recovery Room, Waiting Room, and Workshop and was fully equipped to carry out all forms of dentistry. The provision of a Dental Department on such a lavish scale was, I think, extremely advanced and even to-day there are few provincial non-teaching hospitals where such facilities exist. The Department was staffed by eleven Honorary Dental Surgeons and was run full-time as a Voluntary Clinic of the Hospital for both out-patients and for the treatment of dental conditions in in-patients. The Department was run very successfully on these lines until 1948 when the National Health Service came into effect. This, of course, brought the voluntary principle to an end and the function of the Dental Department as a charitable institution came to an end also. After a period of indecision it was finally decided that the Department would no longer treat out-patients except those referred for specialist treatment, and the number of dental sessions was cut down to those required for this purpose, and for the treatment of dental disease in in-patients.

It will be seen from the foregoing that the Royal Victoria Hospital, Bournemouth, had for a long time been providing a dental service to the inhabitants of the town and it is not so surprising, therefore, that it was eventually requested to provide an Orthodontic Service and thus became, I think, the first non-teaching provincial hospital to do so under the National Health Service Act.

In May, 1949, the Medical Officer of Health for Bournemouth wrote to the Bournemouth and East Dorset Hospital Management Committee asking whether the orthodontic treatment of Bournemouth schoolchildren could be undertaken by the Royal Victoria Hospital. The following month a similar request was made by the Secretary of the Local Executive Council. It is interesting to note that the Hospital Service was thus approached by the two other branches of the Health Service, namely the Local Authority Health Department and the General Dental Service, to provide a specialist service in orthodontics. The request was referred by the Hospital Management Committee to the Western Area Committee of the South West Metropolitan Regional Hospital Board. This Committee referred the matter to its Dental Advisory Committee who advised that a full-time Consultant Orthodontist be appointed. The Regional Board accepted this advice and the post was nationally advertised in January, 1950. The appointment was made in April, 1950, and the Clinic finally opened on Oct. 1, 1950, about eighteen months after the original request had been made.

As the appointment was to a specific Hospital Group with a population of approximately 300,000, it was decided that, to begin

with anyway, only patients residing in the area covered by the Hospital Group would be accepted for treatment. Accordingly a circular letter was sent to all dental surgeons practising in that area advising them of the new facilities available to them. It was stated that patients could be referred either for advice or for treatment, but if for the latter only patients residing in the area could be accepted. I was anxious to limit the area from which I would draw patients for two reasons. Firstly, I did not want the clinic to become completely swamped with patients so that a long waiting list would inevitably be built up. It was thought better to build up the service gradually and to keep it effective over a small area rather than become ineffective over a large one. Secondly, I do not think it is satisfactory to take on patients who have to come long distances for treatment. If a patient is not readily able to attend when required a new factor is introduced which inevitably prolongs the treatment time and reduces the chances of success. Naturally, I have occasionally made exceptions to this rule for children suffering a severe disability and who were otherwise unable to obtain treatment.

The response to the opening of the Clinic was gratifyingly brisk and in a remarkably short time a sufficiently large pool of patients was accumulated to keep the Clinic operating at full pressure. The new service seemed to be appreciated both by the patients and by the dental practitioners. I would particularly like to place on record my appreciation of the extremely co-operative attitude of the dental surgeons in the area. My relationship with them can only be described as cordial, and I am most grateful for the way in which I was made to feel welcome from the very beginning.

On acceptance for treatment it is made clear that the patient remains the patient of the dental surgeon referring the case, and is expected to make regular visits to him for inspections for caries and routine dental care. The patient is referred back to his private dental surgeon or school dental officer for any extractions which may be orthodontically necessary. A full report is sent to the dental surgeon referring the case when a diagnosis and treatment plan has been made. By these means a good liaison is maintained between the orthodontist and the general practitioner which is obviously to the benefit of all concerned.

The staff of the Orthodontic Department consists of 1 Consultant, 1 Clerk-Attendant, and the equivalent of rather more than 2 Dental Technicians. The Hospital actually employs 4 technicians, but they are also engaged on other work.

All patients are X-rayed as a routine and the X rays are done in the General Dental Department by the Dental Sister assisted by the Chief Technician. The standard of mechanical work and of radiography is outstandingly good. The morale and team-spirit of all members of the unit is excellent and it is, I am sure, on this account that a high output of work is maintained.

In cases where surgical intervention is necessary patients are referred to the surgical specialist, Mr. R. G. Torrens, who has two beds in the hospital and a weekly operating session. My thanks are due to Mr. Torrens for his willing co-operation in the treatment of many cases.

The following are two statistical tables showing the progress of the Clinic and an analysis of its work:—

Table I

	1950–1	1951–2	1952–3	1953–4
New patients for advice	20 approx.	70	116	148
New patients for treatment	581	520	446	519
Attendances	3483	5124	5236	6588
Cases completed	10 approx.	25 approx.	100	154

No. on waiting list: 239
Present waiting period: Approx. 6 months.

Comments on Table I.—

1. The number of patients accepted for treatment was far greater than I had expected to be able to take on. This may have been due

to the fact that my previous experience had been in:—

a. A teaching hospital where delays are inevitable for teaching purposes.

b. A part-time local authority clinic. It would seem that if one is permanently in one place one can get through far more work in the equivalent time.

2. There is an encouraging increase in the number of cases being referred for advice.

In 1954 the number of cases referred for advice comprised 22 per cent of the total number of new cases seen.

3. Cases completed refer only to cases completely written off and no longer in retention or under observation. I do not regard this stage as having been reached in most cases until either no further dental development can be expected or, if much active treatment has been done, until all retention appliances have been discarded for a period of up to 18 months. This figure can be expected to rise steeply in the next few years.

4. The waiting list has for some time remained steady at approximately six months. In the vast majority of cases no harm results from a patient having to wait for this period before receiving treatment. I rely on the dental surgeon referring the case to inform me if there is any special reason for urgency, in which case an early appointment is given. This method seems to work well and I do not, therefore, have to waste time calling up patients off the list, sorting them out into urgent and non-urgent cases—a dreary task—and then putting the majority back on the list.

Table II represents a breakdown of the figures for the year ended Dec. 31, 1952, and was compiled at the request of the Ministry of Health:—

Table II.—Table of Statistics of Orthodontic Department, Royal Victoria Hospital, for the Year ended December 31, 1952

Completed	No further appointments	25	191
	Still under observation	101	
	Still in retention	65	
Under treatment	With fixed appliances	169	523
	With removable appliances	354	
Under observation	With extractions	158	384
	Without extractions	226	
Examined and advised	Patients seen	140	184
	Models sent by post	44	
Total new patients			568
Attendances			5024
Removable appliances fitted			502
Fixed appliances fitted			172

Comments on Table II.—

1. *Under observation* does not include patients who have already had treatment with appliances.

Includes (*a*) Patients not yet ready for appliances; (*b*) Not likely to need appliances; (*c*) Treated by extractions only.

2. *Examined and advised—models only.*—I do not regard it as at all satisfactory to give an opinion without seeing the patient. However, I do give a few consultations in this way to practitioners whose patients for some good reason, usually distance, are unable to attend.

3. The proportion of removable to fixed appliances has risen in my practice since recent improvements in clasp design have made it possible to carry out with removable appliances procedures for which I should previously have used fixed appliances.

Figures have their place in an account of this kind, but unless they are related to actual cases they may well prove misleading. In an attempt to avoid this I think it only right and proper to give some indication of the principles and methods used on cases under treatment at the Clinic.

As far as possible cases are treated according to the principles indicated by recent work on skeletal and muscle patterning. I was fortunate in having a long period of collaboration with Mr. C. F. Ballard, and at an early stage became convinced of the soundness of his views on aetiology and diagnosis. I have

derived great benefit from treating my cases on the lines indicated by him at that time and in his subsequent published work.

DIAGNOSIS AND TREATMENT

In the present state of knowledge and for practical clinical purposes I believe that the soundest assumptions on which to base a diagnosis and treatment plan are as follows:—

1. The Apical Base.—By this is meant that the dento-alveolar process, though in itself plastic, behaves as though it were built on a rigid base in the mandible and maxilla respectively. These bases bear for any individual a fixed relationship to the size of the teeth and this relationship rarely changes or can be expected to change either with growth or under the influence of orthodontic treatment.

2. The Skeletal Pattern.—The apical bases bear for any given individual a fixed relationship to each other and to the rest of the skull. Again for practical purposes their relationship does not change, nor can it be expected to change either with growth or as a result of orthodontic treatment. This relationship is usually referred to as the skeletal pattern.

3. Muscle Pattern.—The position of the teeth in relation to the skeletal pattern is influenced by the investing musculature. Here again for practical purposes it is wisest to assume that this muscle patterning does not change as a result of orthodontic treatment. Experience teaches, however, that some favourable changes may occur and in certain types of cases the only hope of a permanent dental improvement may reside in an attempt to bring about a simultaneous change in muscle action.

Extremely unfavourable muscle patterning, however, may make one decide to limit the objective of treatment and not to attempt to establish ideal normal occlusion.

It has been found that by working on the above assumptions certain procedures which used to be thought necessary have been eliminated. As a result reasonable results can be obtained more quickly.

For example in such conditions as "overcrowding" where this can be seen to be due to the size of the teeth being too large for the size of the apical base, I no longer attempt to gain space by lateral expansion of the arches. In such cases suitable teeth are extracted and the remainder brought into alinement.

I no longer find it necessary to "open the bite" before retracting the upper incisors. In Class II, Division I cases where the overbite is considerable I find that this excessive incisor overlap corrects itself automatically when the axial relationship is improved. Hence the long procedure of bite opening is eliminated and the result achieved sooner.

In cases where the anteroposterior relationship of the arches is abnormal cases are treated on the assumption that the apical base relationship will not change and an attempt is made to bring about an improved position of the teeth on their apical bases and within the existing muscle pattern.

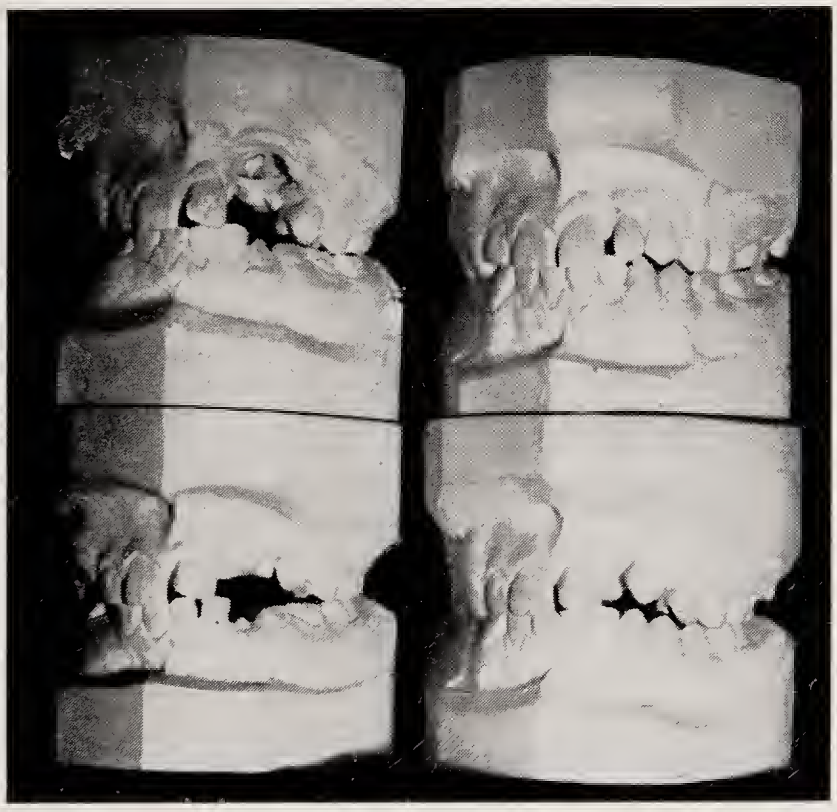
Hence three appliances which used to be the standby of orthodontics have, as far as I am concerned, been almost completely discarded. These are the bite plate, the Badcock, and the inclined plane. The use of these appliances and the beliefs which led to their use were, I submit, responsible for a great deal of unnecessary and ineffective orthodontic treatment in the past.

Finally, I would say that since being brought much more forcibly face to face with the problem of bringing orthodontics to the vast number of children who require it, my approach to treatment has undergone a modification. It is difficult to put this modification into words without giving a false impression, but briefly I would say that I now tend to base my objective less on the achievement of some arbitrary criterion of normal occlusion and more on the elimination of the conditions from which the patient is actually suffering or from which he may suffer in the future.

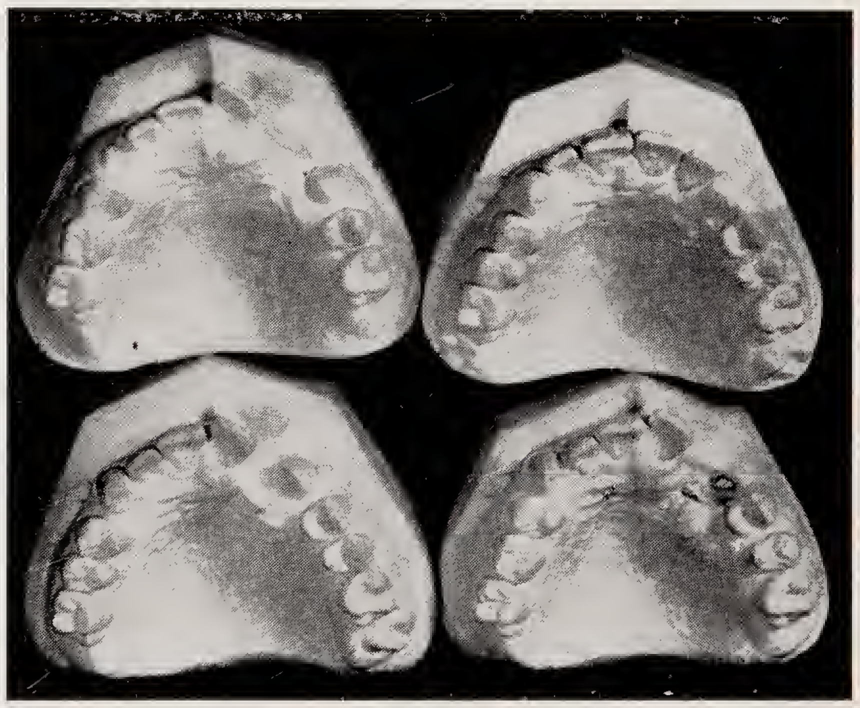
ILLUSTRATIVE CASES

The following illustrations are of cases treated at the Bournemouth Clinic. They have been selected to show as far as possible typical treatments of the conditions most frequently met.

A

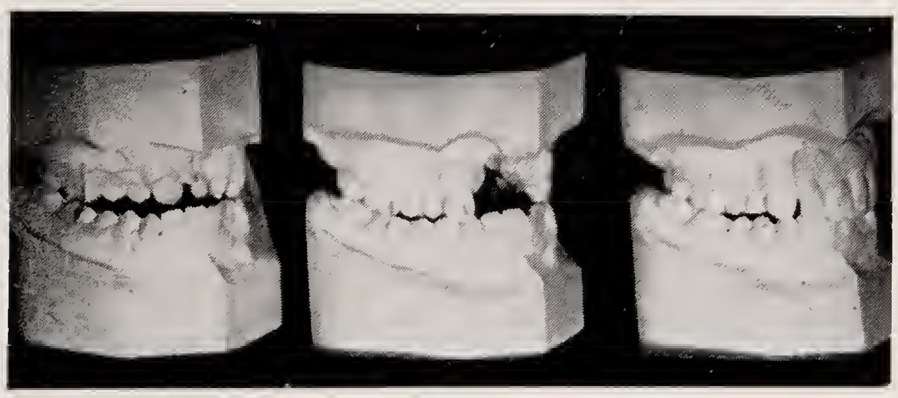


B

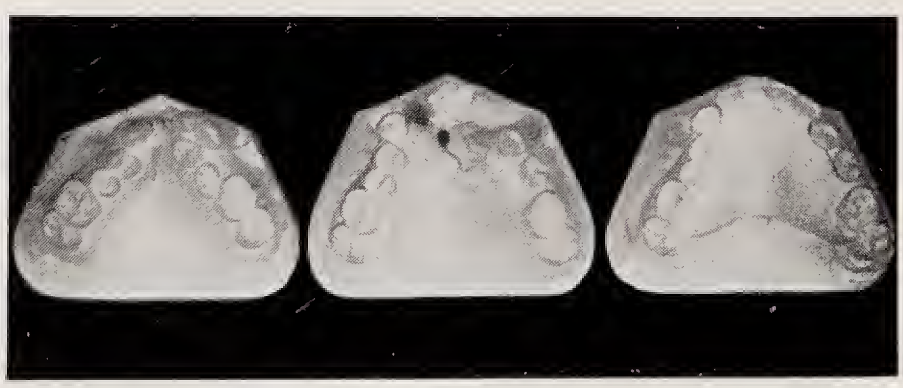


C

Fig. 1.—*Case A.* A, X-rays showing condition before and after removal of odontome. B, Front view of models showing condition before exposure of $\underline{|23}$, after exposure of $\underline{|23}$, after eruption of $\underline{|23}$, and after orthodontic treatment. C, Occlusal views of upper models shown in B.



A



B

Fig. 2.—*Case B.* A, Models showing condition before treatment, after expansion of maxillary segments, and after fitting denture. B, Occlusal view of upper models.

Case A (*Fig.* 1).—Age at commencement $12\frac{1}{2}$ years. Perfect example of Class I case with severe but local abnormality. Odontome removed some months before first seen.

$\underline{|23}$ exposed (Mr. Torrens), December, 1952.

$\underline{|23}$ fully erupted and twin wire arch fitted, December, 1953.

Twin wire arch removed. Retention appliance fitted, August, 1954.

Total visits, 22.

Estimated surgery time, 3 hours.

Duration of treatment, 2 years, 3 months.

Case B (*Fig.* 2).—Age at commencement 13 years 1 month. Double cleft with removal of premaxilla.

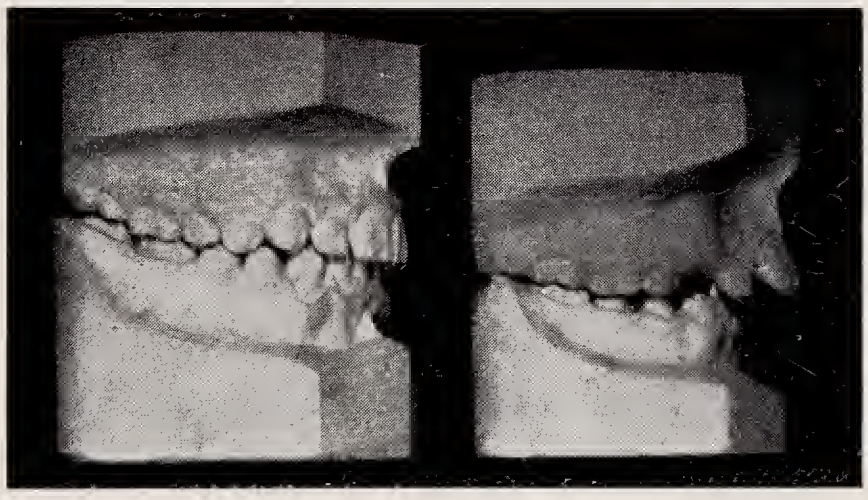
Fixed appliances fitted, November, 1950.

Fixed appliances removed and denture fitted, March, 1952.

Total visits, 32.

Duration of orthodontic treatment, 1 year, 4 months.

Estimated surgery time, $4\frac{1}{2}$ hours.



A

B

Fig. 3.—*Case C.* A, Models before and after treatment with oral screen. B, Occlusal view of models.

Case C (*Fig.* 3).—Class I case. Good arches. Incisor irregularity only.

Oral Screen fitted, March, 1951.

Occlusion normal, July, 1952.

Screen discarded, August, 1953.

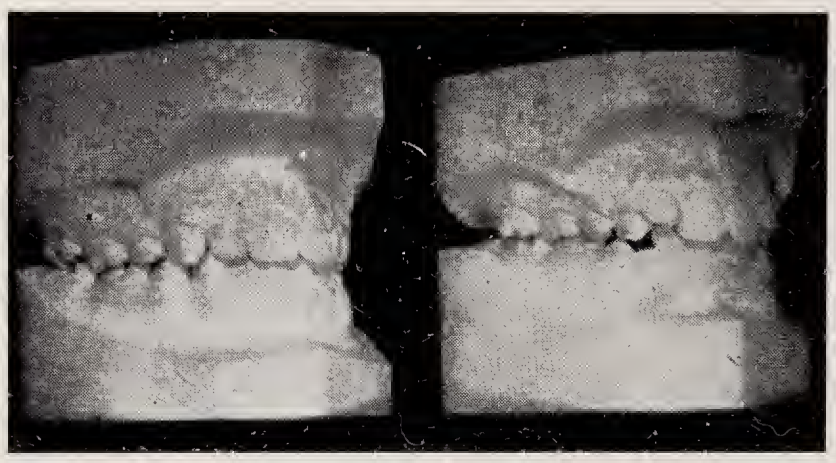
Total visits, 12.

Duration of treatment, 2 years, 5 months.

Estimated surgery time, 1 hour.

Note: (1) improvement of incisor overlap—no bite plate; (2) improvement in shape of upper arch—no badcock.

Case D (*Fig.* 4).—Aged 10 years. Class I case "overcrowding" due to teeth large in relation to size of apical bases.



A

B

Fig. 4.—*Case D.* A, Models before treatment and 2 years, 5 months after extraction of $\frac{4C|C4}{4C|C4}$. B. Occlusal view.

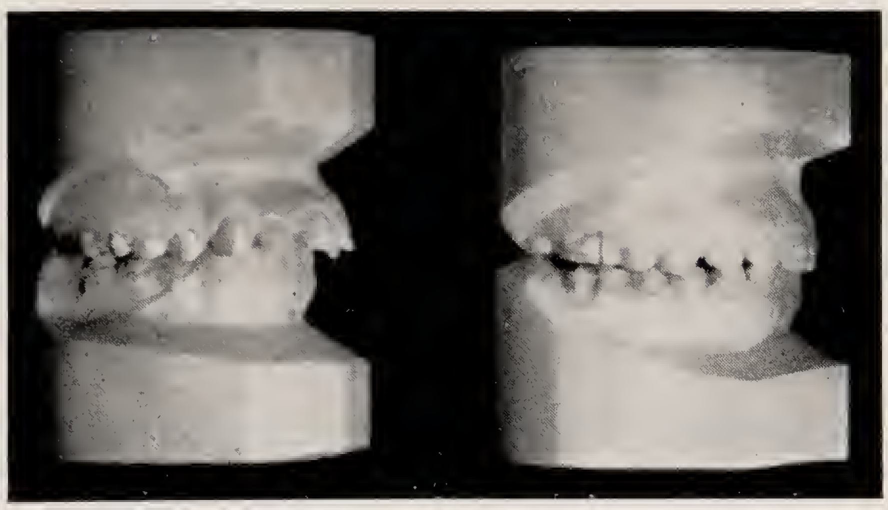
$\frac{4C|C4}{4C|C4}$ extracted, January, 1951.

Case concluded, October, 1953.

Duration of observation, 2 years, 10 months.

Total visits, 7.

Estimated surgery time, 45 minutes.



A

Total visits, 25.

Duration of treatment, 2 years, 9 months.

Estimated surgery time, 2 hours, 40 minutes.

Case F (*Fig.* 6).—Age at commencement 13 years 2 months. Class II, Division I with unfavourable muscle and skeletal pattern. $\overline{5|5}$ missing.

Fixed appliances fitted, February, 1951.

Fixed appliances removed, February, 1952.

Still wearing retainers.

B

C

Fig. 5.—*Case E.* A, Models before and after treatment with intermaxillary traction. B, Full-face photograph before and after treatment. C, Profile photograph before and after treatment.

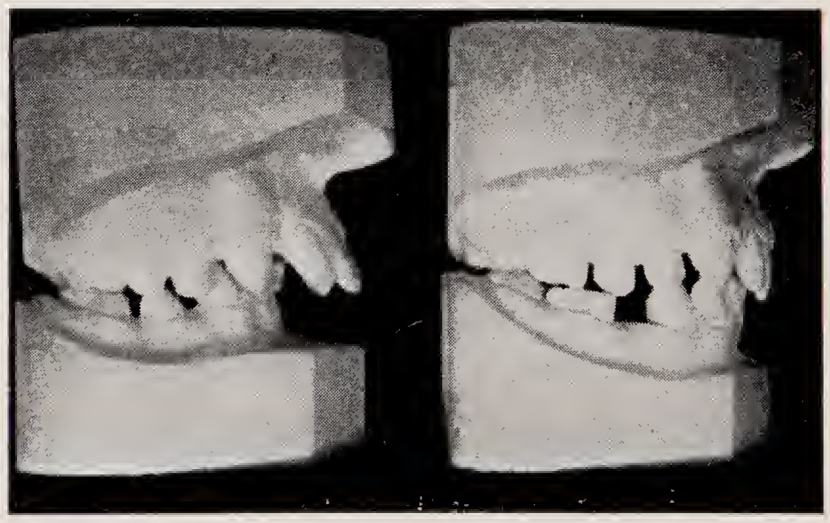
Case E (*Fig.* 5).—Aged 12 years. "Classic" Class II, Division I. Muscle and skeletal pattern favourable. Relationship of teeth size to apical base size good.

Intermaxillary traction appliances fitted, January, 1951.

Normal occlusion achieved, July, 1951.

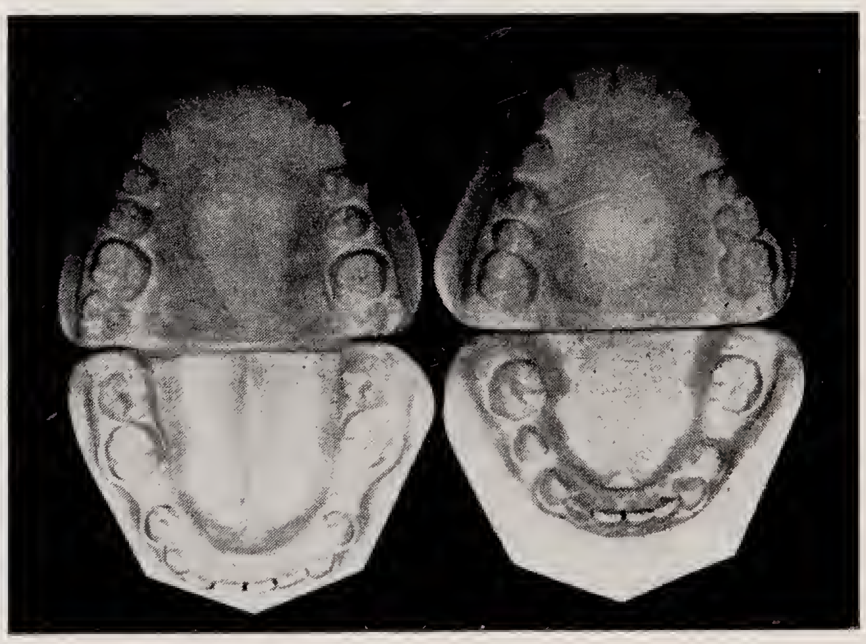
Retainer fitted, January, 1952.

Retainer discarded, October, 1953.



B

A



C

Fig. 6.—*Case F.* A, Photograph before and after treatment. B, Models before and after treatment. C, Occlusal view of models.

Active treatment, 1 year.
Total visits to date, 34.
Estimated surgery time to date, 3½ hours.

Case G (*Fig.* 7).—Aged 11 years. Class II, Division I. $\underline{4|4}$ extracted owing to discrepancy between tooth size and apical base size.

Fixed appliance to retract $\underline{3|3}$ fitted, November, 1953.

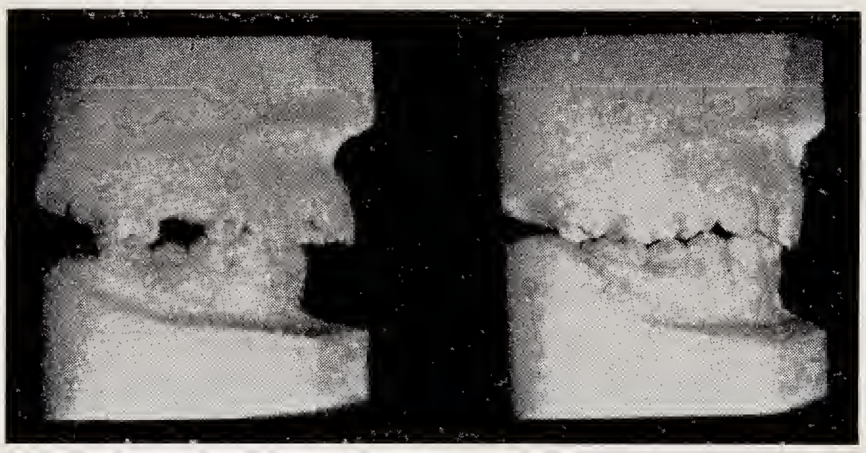
Fixed appliance removed. Removable appliance fitted, February, 1954.

Retainer not yet completely discarded.

Estimated surgery time, 2 hours.
Retainer not yet completely discarded.

Case J (*Fig.* 9).—Aged 11 years. Class III case treated with removable appliance.

Plate fitted, April, 1952.
Incisors normal, July, 1952.



A

B

Fig. 7.—*Case G.* A, Model before and after treatment. B, Occlusal view of models.

Duration of active treatment, 1 year.
Total visits, 16.
Estimated surgery time, 2 hours.

Case H (*Fig.* 8).—Aged 13 years. Example of case where $\underline{6|6}$ had to be removed because of caries.

Removable appliance fitted, November, 1952.

Plate discarded, December, 1952.

$\frac{6|6}{6|}$ extracted later.

Duration of appliance treatment, 8 months.

A

B

Fig. 8.—*Case H.* A, Models before and after treatment. B, Occlusal view of models.

Active treatment completed, April, 1954.

Duration of active treatment, 1 year, 5 months.

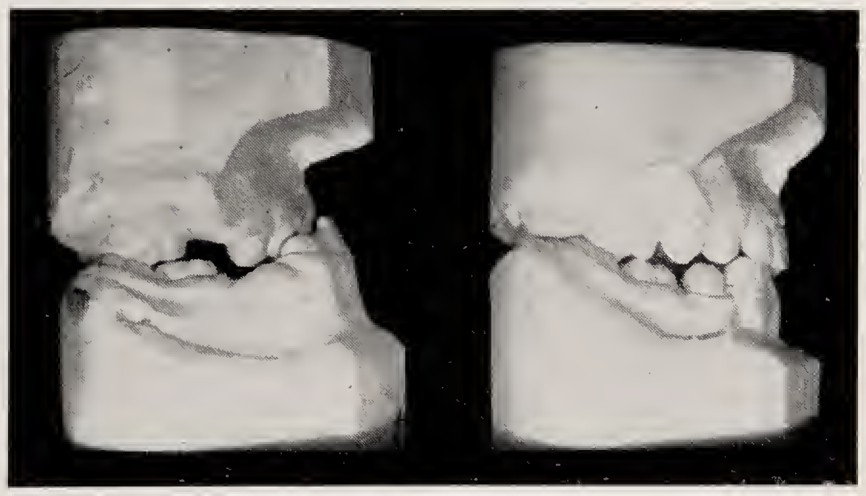
Total visits, 22.

Total visits, 9.
Estimated surgery time, 45 minutes.

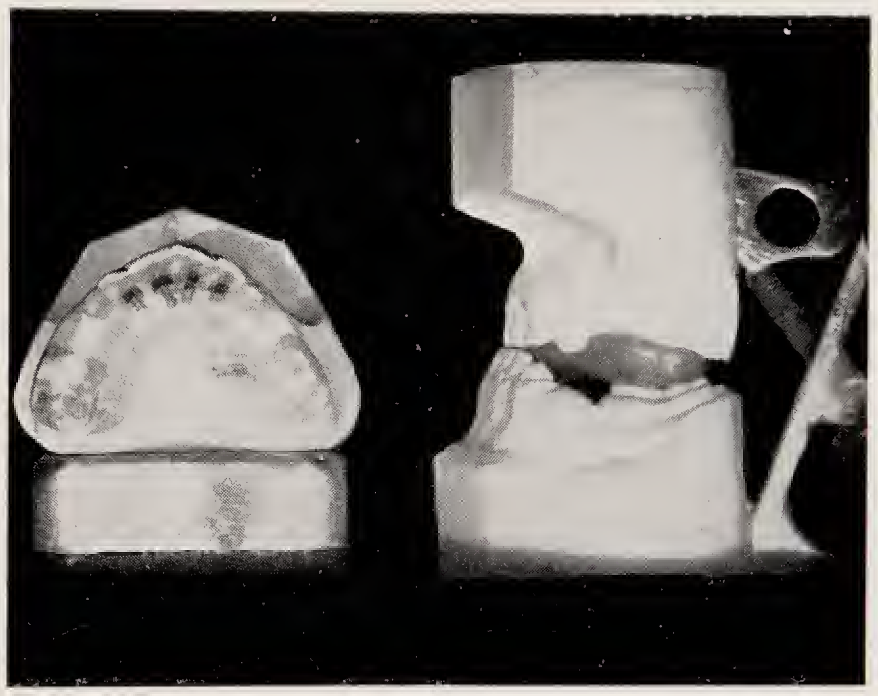
Case K (*Fig.* 10).—Aged 14 years. Class III case treated with fixed appliance.

Fixed appliance fitted, December, 1950.
Fixed appliances removed, April, 1951.
No retention.

Duration of active treatment, 4 months.
Total visits, 9.
Estimated surgery time, 75 minutes.



A



B

Fig. 9.—*Case J.* A, Models before and after treatment with removable screw appliance. B, Models articulated after eliminating bite of accommodation and occlusal view of appliance.

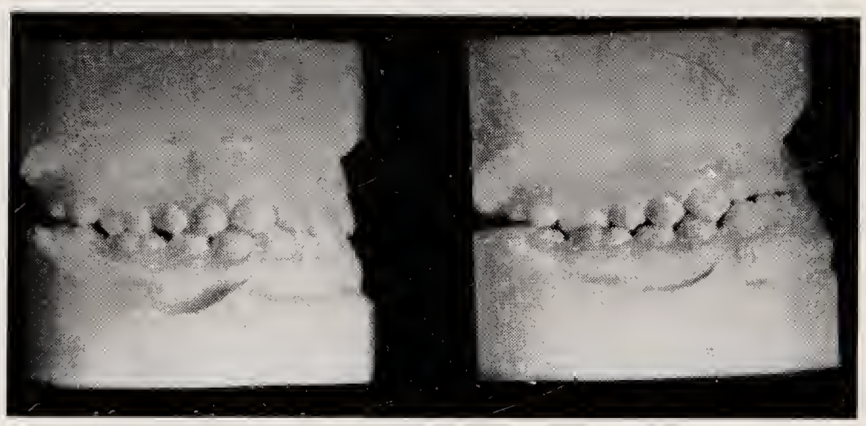


Fig. 10.—*Case K.* Models before and after treatment with reversed intermaxillary traction.

DISCUSSION

Mr. G. C. Dickson, in opening the discussion, said that at Birmingham there was an orthodontic service which was of a similar nature to that at Bournemouth which had been started about a year later. It had been begun in a rather different way, in that an effort had been made to advise as many dentists as possible on the way to treat orthodontic patients.

With regard to Mr. Hooper's point about dentists not wanting to treat orthodontic cases, he thought the chief reason for that was that insufficient time was given to instructing undergraduates in orthodontics. The newly qualified dental surgeon was quite prepared to make any sort of partial denture but he was not prepared to make any orthodontic appliances.

He would like to ask whether Mr. Hooper was still treating children only from the 300,000 population of Bournemouth or whether he had extended the area from which he drew his patients. If each orthodontist dealt with a population of only 300,000, about 170 orthodontists would be needed for England and Wales, and as that was a number which it would be impossible to achieve in the foreseeable future it would be necessary to utilize the services of the general dental practitioner in treating orthodontic patients, and the undergraduate teaching in the subject would therefore have to be increased. It was obvious that undergraduates could not be comprehensively instructed in diagnosis, but he thought that the construction and manipulation of removable appliances should be regarded as a minimum for the undergraduate curriculum.

In the meantime some source of orthodontic treatment in addition to the consultant and the general dental practitioner must be found, and he would suggest that some appointments of the Senior Hospital Dental Officer grade should be made throughout the country. If that was done, the consultants would be wasting a good deal of their time on minor treatments.

He did not agree with Mr. Hooper that the bite plate was no longer necessary. The correction of the axial inclination of the incisors was obviously essential for the treatment of an overbite, and he thought that in very many cases the bite plate was a good short cut to that.

He would like to express his admiration for the tremendous amount of good Mr. Hooper is doing at Bournemouth. Further development of such services in other parts of the country will at last bring hope to the thousands of dentally deformed children who are

not fortunate enough to reside within travelling distance of a teaching hospital.

Miss M. E. Myers deplored the suggestion that partially trained orthodontists should be made senior hospital dental officers and said there were a good many trained orthodontists in the southern counties who had the status of ordinary dental officers.

Mr. G. Taylor, referring to Mr. Hooper's statement that he dealt with a population of 300,000 in Bournemouth, said that if the population there lived to the age of 60 it would mean that 5000 people were born there every year. If Mr. Hooper was treating 500 cases a year, it would seem that one child in ten suffered from some orthodontic deformity. It was known that that was not the case, and what had happened was that Mr. Hooper had gone to Bournemouth and was now treating orthodontic deformities in all the age groups of that district. When he had finished treating them, he would get cases at a much reduced rate, as the children would be virtually from one age group.

Mr. J. H. Hovell said that Mr. Hooper worked about three times as quickly as any other orthodontist whom he knew, so that it was not 170 orthodontists that would be needed, as Mr. Dickson had said, but three times that number.

An important question was whether the consultant orthodontist in the Health Service should do any treatment. He felt that Mr. Hooper, who was an expert diagnostician, was to a certain extent wasting his time in doing treatment. He thought that in a hospital orthodontic service the consultant's work should be confined to diagnosis and that he should have working under him people who were trained in orthodontic mechanical procedures. These people might or might not be general dental surgeons, as these had plenty of other work to do. If they were general dental surgeons, they should be those who had had special training and were more skilled in the mechanical procedures of orthodontics. If that scheme were adopted, how many cases could Mr. Hooper supervise?

Miss L. M. Clinch said she thought that the scheme suggested by Mr. Hovell might be a good one but highly trained technical dental surgeons would be needed for it, and they did not exist now. One disadvantage in an orthodontist advising on treatment was that he could not be sure that the dental surgeon to whom he was speaking or writing understood what he wanted done. That was probably due to lack of undergraduate teaching. She certainly would not say that Mr. Hooper was wasting his time in treating cases himself.

With regard to Mr. Hooper's statement that he never expanded an arch, what did he do if the upper molars and premolar or deciduous molars were in lingual occlusion to the lowers in a normal arch relationship?

Mr. Jason Wood, in supporting the remarks made by Miss Clinch, said it was impossible to know what a general dental surgeon could or could not do in the way of orthodontic treatment when he was advised on it, and this system was very unsatisfactory. He thought that all cases should be treated by experts.

Mrs. Michaelis said she felt sorry for the patient who Mr. Hooper said would have to wear a lower retainer all his life. She hoped that he would be allowed to have two neat bridges put in, one on each side. That could surely be done by one of the many skilled dental surgeons to whom reference had been made.

Mr. H. L. Leech said that in his experience undergraduate students could be taught to diagnose orthodontic cases quite accurately and it was only by having a knowledge of diagnosis that they could decide which cases they could treat and which they could not. He thought that most of the treatment planning afterwards came from experience.

Mr. H. G. Watkin said that an orthodontist could diagnose a case very well without seeing the patient if models, well made and articulated, were sent to him, also X rays and sometimes photographs. He thought that this service ought to be developed further.

Mr. Walpole Day, referring to the question of undergraduate teaching in orthodontics, said that in Birmingham for many years orthodontics had been considered a postgraduate subject and the directions given had been to concentrate on diagnosis and not on treatment. The unfortunate results of that were now being experienced, and so the policy was now being modified to include treatment. As one who had been concerned with undergraduate training for a long time, he would say that very few undergraduates were born orthodontists.

He was glad that the Royal College had instituted a diploma in orthodontics, as that would encourage students to devote more time and study to the subject.

Miss R. Caseley deprecated the practice of referring orthodontic cases to the general dental practitioner for treatment, because she thought that general dental practitioners at the present time were fully occupied in carrying out the very essential conservative treatment.

Mr. C. F. Ballard said he thought that the remarks made by Mr. Hovell and a number of other speakers showed that the Report of the B.D.A. Committee on Orthodontic Services was correct. It was the view of that Committee that the most important part of the teaching in undergraduate schools was diagnosis, and he thought that, as orthodontic diagnosis was fundamental to all branches of dentistry, it should not be called "orthodontic diagnosis".

With regard to appliances, as a result of the courses that had been held for general dental practitioners at the Eastman Dental Hospital and the courses which were being held there for technicians, it was felt that the general dental practitioner should be taught appliance design and that the technician should be taught how to make the appliances.

Mr. E. K. Breakspear referred to the very short surgery time which Mr. Hooper estimated for his cases and said he thought it was important to recognize that different people worked at different paces.

He would like to ask whether Mr. Hooper took his own record models, whether he made his bands in the mouth or whether they were made by a technician on the model, and whether he personally explained the treatment and care of appliances, etc., to the patient, or whether that was done by a nurse.

Mr. H. E. Wilson said he had noticed that in Mr. Hooper's tables there was no reference to patients not keeping their appointments. It was his own experience that a large proportion of patients started treatment but did not complete it, and he would like to know whether that was Mr. Hooper's experience also.

Mr. G. Sperryn-Jones said that from a general dental practitioner's point of view he deplored the gap between orthodontics and children's dentistry. He thought that, instead of more orthodontists being trained, the available man-power would be better employed in concentrating on children at a very early age and putting the emphasis on conserving the primary dentition at all costs, thus

reducing the amount of orthodontic treatment needed later on.

Mr. P. G. Oliver said his experience was that children were sent for orthodontic treatment at a very early age and he thought it would be a good plan to suggest a minimum age at which the greatest amount of good would be obtained from a consultation.

He thought that as time went on the schemes should be expanded so that the consultant worked principally in a consultant capacity and much of the actual treatment was done by trained senior clinicians who were not of consultant status. That team work, he thought, would give the best results.

Mr. S. G. McCallin said that an orthodontist with Mr. Hooper's background and training appeared to be able to do a tremendous amount of excellent work employing very little chairside time per case. Therefore, he would suggest the best course to adopt would be to make it possible for more dental practitioners to acquire the same high standard of skill as a solution to the orthodontic needs of the public.

The President, referring to the fact that Mr. Hooper was now taking on cases at the rate of about 500 a year, said that he would reach a point where he could not absorb them at that rate, because he would not be finishing them fast enough to do so. Did Mr. Hooper feel that he was now reaching the limit and would need some help?

He thought that consultants, when advising general practitioners, should come to a level that the general practitioner could understand and should be careful to give advice which he could carry out easily.

Mr. J. D. Hooper, in replying to the discussion, said he thought there must be a snag in Mr. Taylor's statistics but he would bear his point in mind.

On the question of consultants confining themselves to advising, that was undoubtedly the ideal state of affairs, but what was a consultant to do when Practitioner A referred a case to him which he knew could be treated quite well by Practitioner B? In the present situation, the consultant could not refer Practitioner A's case to Practitioner B. Many general dental practitioners carried out simple orthodontic procedures themselves and did not trouble consultants with them. As things were at the moment, the consultant could not confine himself entirely to giving advice. Personally he would not like to be in that position; he enjoyed his work chiefly because of the contact he had with the patients, and he would not like to give up treating them himself. Moreover, he thought that the consultant with his greater experience did in fact treat the cases more quickly, because he saw the short cuts and took them. He did not think that a consultant could make an absolute diagnosis at the first visit, because he was dealing with a child that was growing and developing, and he would probably want to modify his treatment plan as time went on.

In reply to Miss Clinch's question, he would say that he did not expand an arch to get space. He had discarded the Badcock plate as a space-gaining appliance. If there was a lingual occlusion he certainly treated it by expanding the arch.

The patient to whom Mrs. Michaelis had referred could have two bridges, but they would not necessarily support his lower labial segment. He thought that a little skeleton denture would be a good idea, and that would in effect be a retention plate as well.

With regard to the remarks made by Mr. Leech and Mr. Ballard, he agreed that a knowledge of orthodontic diagnosis was a help to students in other branches of dentistry; therefore he thought that they should continue to be taught diagnosis, and, if possible, they should be taught the construction of appliances also. At the present time undergraduates were not given sufficient instruction in orthodontics, but he did not think the fault lay with the dental schools; it lay with the examining bodies or the people who drew up the curriculum.

With regard to Mr. Watkin's remarks, he agreed that diagnosis should be done from models if the practitioner could not get an opinion in any other way, but it was very much better for the orthodontist to see the patient.

He agreed with Mr. Day that the diploma in orthodontics was an excellent thing to encourage students to take an interest in the subject and to study it.

It was not for him to decide the question of priorities, to which Miss Caseley had referred. It was obviously no use doing orthodontics if the conservation work was not done.

With regard to Mr. Breakspear's remarks, he got through the work so quickly because he streamlined it and also because he had a first-class surgery assistant and secretary.

He took his own models of the cases that he was treating himself, but the patients who were sent to him for advice brought their models with them. He made his bands in the mouth, but his surgery assistant did the welding and trimming up. He did not allow her to explain the treatment to the patients; he did that himself.

In reply to Mr. Wilson, he had not intended to concea the fact that there was wastage, and he could look up the figures for that. If patients did not keep their appointments and did not send any excuse, he did not send for them; he left it to them to ask for another appointment.

Mr. Sperryn-Jones had made a good point about children's dentistry. A great many orthodontic cases were complicated by the lack of good intelligent children's dentistry, but it was not absolutely essential to preserve every deciduous tooth for orthodontic reasons. For instance, Class III cases did not suffer very much if they lost their lower deciduous molars.

He did not think that any definite age could be stated at which cases should be referred. It depended on the type of case, whether teeth had been extracted or were likely to be, the state of caries, and so forth.

In reply to the President, he did not know when he would reach his limit in the number of cases. He had nearly completed five years at the work, so he supposed he would soon start discarding patients much more quickly. Large numbers of those who had not yet been discarded came only once every six months or once a year.

He agreed with the President that it was no use an orthodontist advising a general practitioner to put in an appliance which the general practitioner could not construct. The advice given should be of a practical commonsense nature which the general practitioner could carry out.

On the motion of the President, a vote of thanks was accorded to Mr. Hooper, and the meeting then terminated.

IDEAL DENTAL OCCLUSION IN THE PRIMATES

By **J. R. E. MILLS,** M.Sc., F.D.S., D.Orth.

THE Primates form one of the main orders of Mammals in the classification evolved by Linnæus, and since modified by other authors. This order is usually divided into two sub-orders, which Simpson (1945) calls the Anthropoidea and the Pro-Simii. The former comprises the New World monkeys, from Central and South America, the Old World monkeys, from Asia and Africa, and a third group which consists of the anthropoid apes and man himself. The other sub-order, the Pro-Simii, is less well-known, but in many ways more interesting. It comprises the lemurs, lorises, and tarsiers, found in relatively limited areas of Asia and Africa, and notably in the island of Madagascar. Its most primitive member is a tree-shrew from the Malayan archipelago called *Tupaia*, which has a particularly interesting dentition, and to which I shall refer in some detail later.

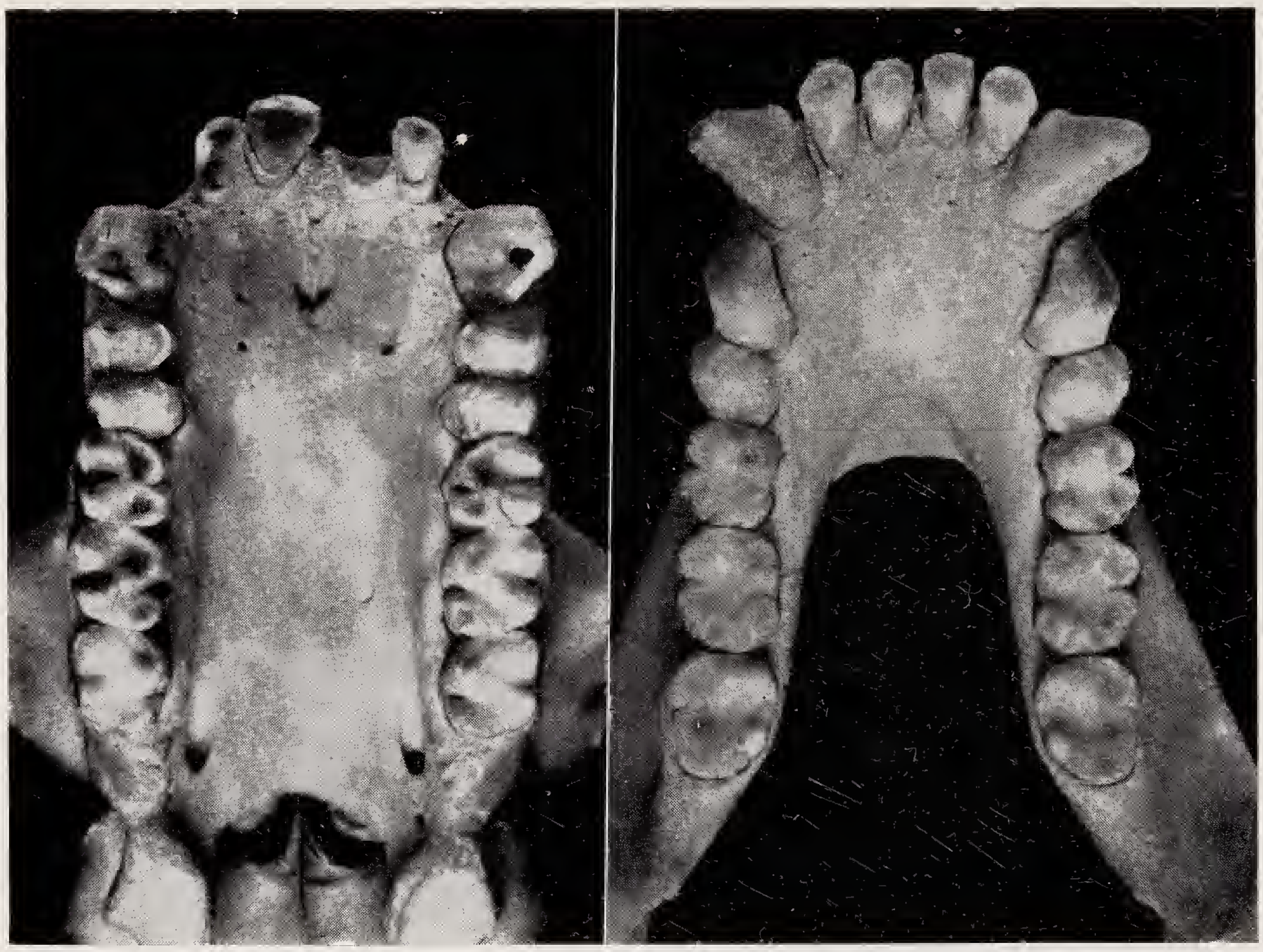


Fig. 1.—The upper and lower dental arches of *Gorilla*.

The dentition of the primates is important for two reasons: Firstly, because it has remained remarkably generalized, with few of the specializations which tend to fog the picture in other orders, and secondly because it is the order to which we, ourselves, belong, and findings in the other Primates may, in some cases, be applicable to man.

Their dentition has been studied in detail by numerous authors. However, the non-human members of the order have been studied most by palaeontologists, in connexion with the study of comparable fossil material, and since the latter is usually fragmentary, relatively little attention has been paid to their occlusion, and practically none to their chewing mechanism.

Cope (1889) and Gregory (1922, 1934, a) have produced occlusal diagrams to illustrate the relationships of the cusps in centric

Given at the Sheffield meeting held on May 6, 1955.

occlusion, while Ryder (1878), who was among the first to investigate this field, appreciated that the cusps of the lower molars, in the majority of mammals, slid between the corresponding cusps of the upper molars in that action which we usually call lateral excursion. Gregory (1920) showed this to be the case in the fossil lemurs *Notharctus* and *Adapis*, basing his findings on the evidence of the wear facets on the teeth. Butler (1952) has demonstrated a similar condition in the Perissodactyls, also using the wear facets to provide his evidence. The last author has shown this movement of the lower cusps between the corresponding upper ones, as the jaw slides from the lateral position to the centric one, and also, as the movement continues, that the lower buccal cusps come into contact with the upper lingual ones.

My attention was first directed to this dynamic occlusion of the teeth—that is, the movement of the teeth during chewing—on examining the skull of the gorilla. Since this was, in fact, the first to be examined, and since it shows a fairly typical picture, I propose to describe the condition in this specimen, and my methods of investigation, and then consider other genera in detail.

The dentition of the gorilla is shown in *Figs*. 1, 2. It is of all the primates the most like that of man. It has the same dental formula of $\frac{2.1.2.3}{2.1.2.3}$ and the general form of the teeth is not unlike our own. The lower molars are all of the five-cusped pattern, while in the upper molars the distolingual cusp, or hypocone, is larger than in most modern human dentitions. The main difference between the two lies, however, in the canines, which are large and tusk-like in the male gorilla, and still enlarged, although to a lesser extent, in the female. As a result they project above the general level of the occlusal plane, and become interlocking. This fact has caused many comparative odontologists, including so great an authority as Keith (1913) to deny the possibility of any lateral excursion in the great apes, and to state that chewing takes place by a purely orthal, or vertical hinge-like action. Shaw (1917) has shown that such a mechanism would be very unsatisfactory, and that the most mechanically efficient method of comminuting the food is by means of a shearing action, in which one plane surface moves across another, remaining parallel, and in as close contact as possible throughout.

Fig. 2.—Lateral view of the dentition of *Gorilla*, (*left*) in centric occlusion, (*right*) at the end of lateral excursion.

In fact, as Gregory (1916) has pointed out, a wide degree of lateral slide is possible in the gorilla, but the effect of the large canines is to limit it to a single narrow path. This is shown in *Fig*. 2. On the left we see the cheek teeth in centric relation, with the uppers slightly overlapping the lowers, while on the right the lower molars have moved laterally. The upper canine slides between the lower canine and first premolar, while the lower canine slides between the upper lateral incisor and canine.

However, it is one thing to say that such a lateral slide is possible, and another to say that it does, in fact, take place. Some proof

is necessary. As will be realized, it is difficult to obtain the co-operation of a live gorilla, but fortunately the chewing action leaves evidence behind it in the form of wear facets on the teeth. These facets appear, macroscopically, as flat, highly polished areas on the cusps of the molar teeth. They can be

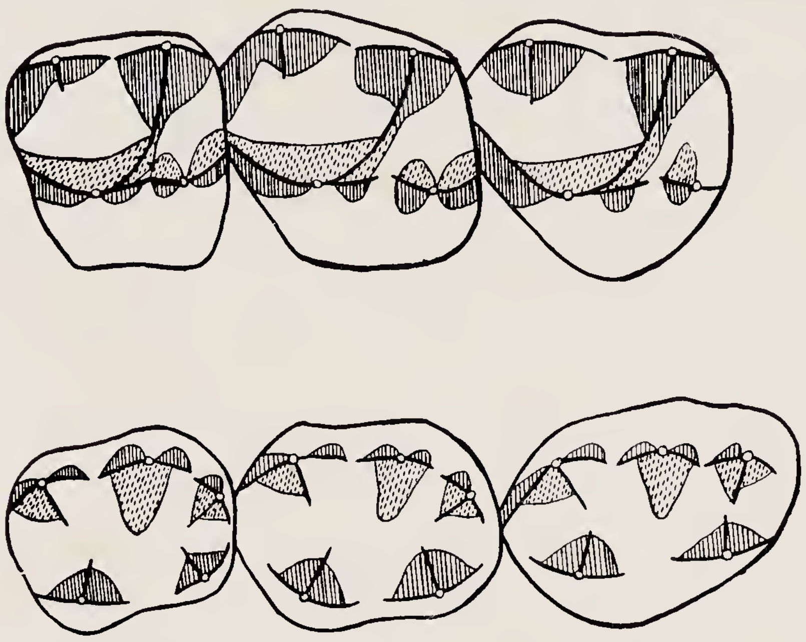


Fig. 3.—Plan view of the upper and lower molar teeth of *Gorilla*, showing the pattern of wear facets found on the teeth. The mesial is to the left of the diagram, and the buccal to the top.

seen more readily under low-power magnification, if the specimen is slowly turned about until the light strikes it at a favourable angle.

Unfortunately, a difficulty was immediately encountered, although this later proved to exist only in the great apes, and to a lesser extent in the Old World monkeys. It was that, during wear of the teeth, the enamel of the molar crowns is very quickly worn through, and the dentine exposed. Once this has happened wear becomes more rapid, and the facet pattern is quickly destroyed. However, this was overcome by careful selection of specimens, one set, of juvenile individuals, being used to examine the first two molars, and another, of slightly older animals, for the second and third molars. By the time the third molar comes into occlusion, the first is usually extensively worn. Thus the diagram of facets shown in *Fig.* 3 is essentially a composite picture, with the second molar providing an overlap. In making this examination I was fortunate to have access to a large collection of skulls of Primates in the collection of the British Museum (Natural History).

Fig. 3 shows, then, the facets found on the upper and lower molars of the gorilla. It will be seen that on the upper molars there are three sets of facets. Two of these, shaded by means of continuous lines, face lingually, while the third, shaded by means of broken lines, or stippling, faces buccally. On the

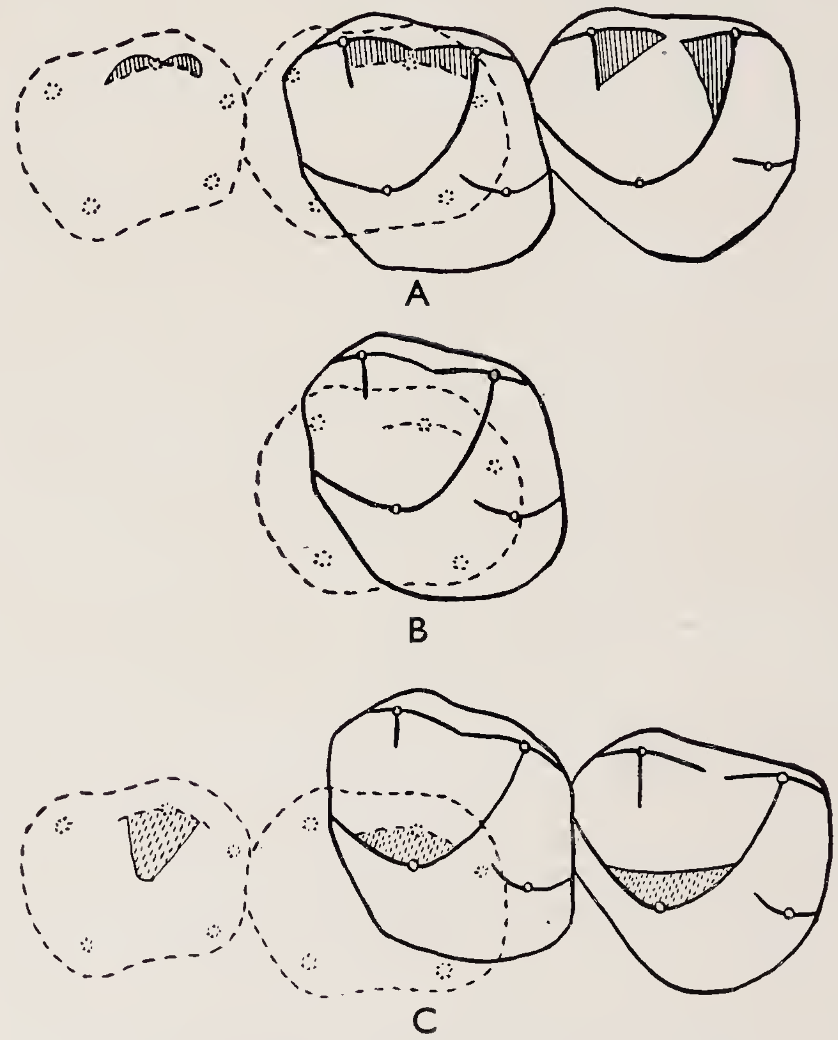


Fig. 4.—The upper and lower second molars of *Gorilla*, superimposed; A, During the buccal phase of occlusion, B, in centric occlusion, and C in the lingual phase. The shaded areas indicate the areas of shear between the hypoconid and neighbouring cusps. In A and C are also shown the lower first and upper third molars, to illustrate the facets which result therefrom. (Upper teeth shown by continuous, lower by broken, lines.)

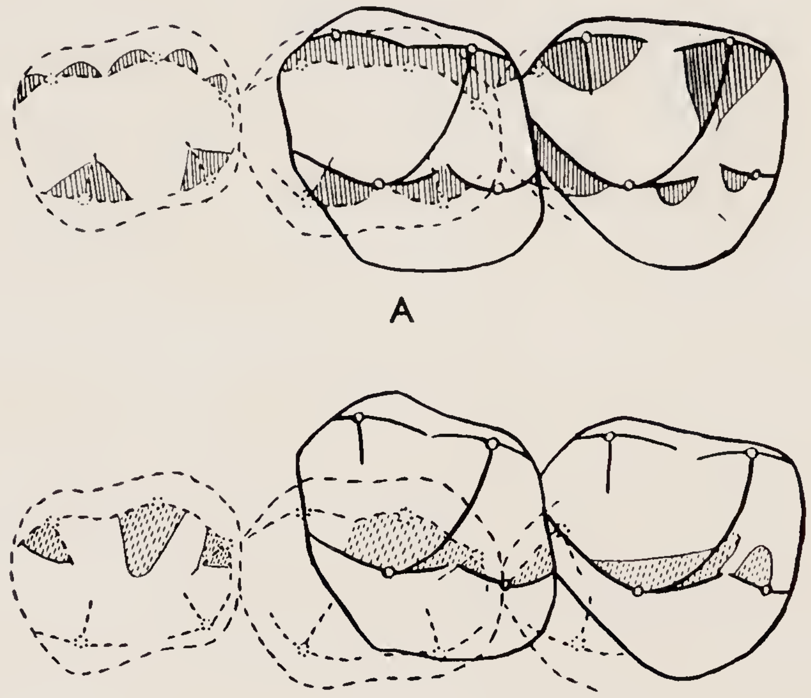
lower molars, on the other hand, the position is reversed; one set faces lingually and two buccally.

Now, if we examine these facets under somewhat higher power, it will be seen that they are not as flat as would at first sight appear. They are, in fact, covered by fine scratch marks, produced by the coarser particles of food. Moreover, in any given facet, these scratch marks, or at least the overwhelming majority of them, are parallel and therefore serve to indicate the direction of jaw movement which produced the facet in question. In fact, the lines used in shading

the facet areas in *Fig.* 3 follow approximately the direction of the scratch marks; those shown by continuous lines running directly transversely, and those shown by broken lines running at a slight angle. It is not, of course, possible to tell by this method whether the chewing motion was from buccal to lingual or vice versa, or, indeed, a mixture of the two.

Turning now to the manner in which these facets are produced, let us consider firstly those on the distobuccal cusp, or hypoconid, of the lower molar. It will be seen from *Fig.* 3 that there are three facets on this cusp; two facing buccally (indicated by continuous shading) and one lingually (stippled). In *Fig.* 4 B we see the second upper and lower molars superimposed in centric relation. It will be seen that in this position the hypoconid occludes in the central fossa of the upper molar. This, incidentally, is a primitive arrangement, which is remarkably constant throughout the Primates.

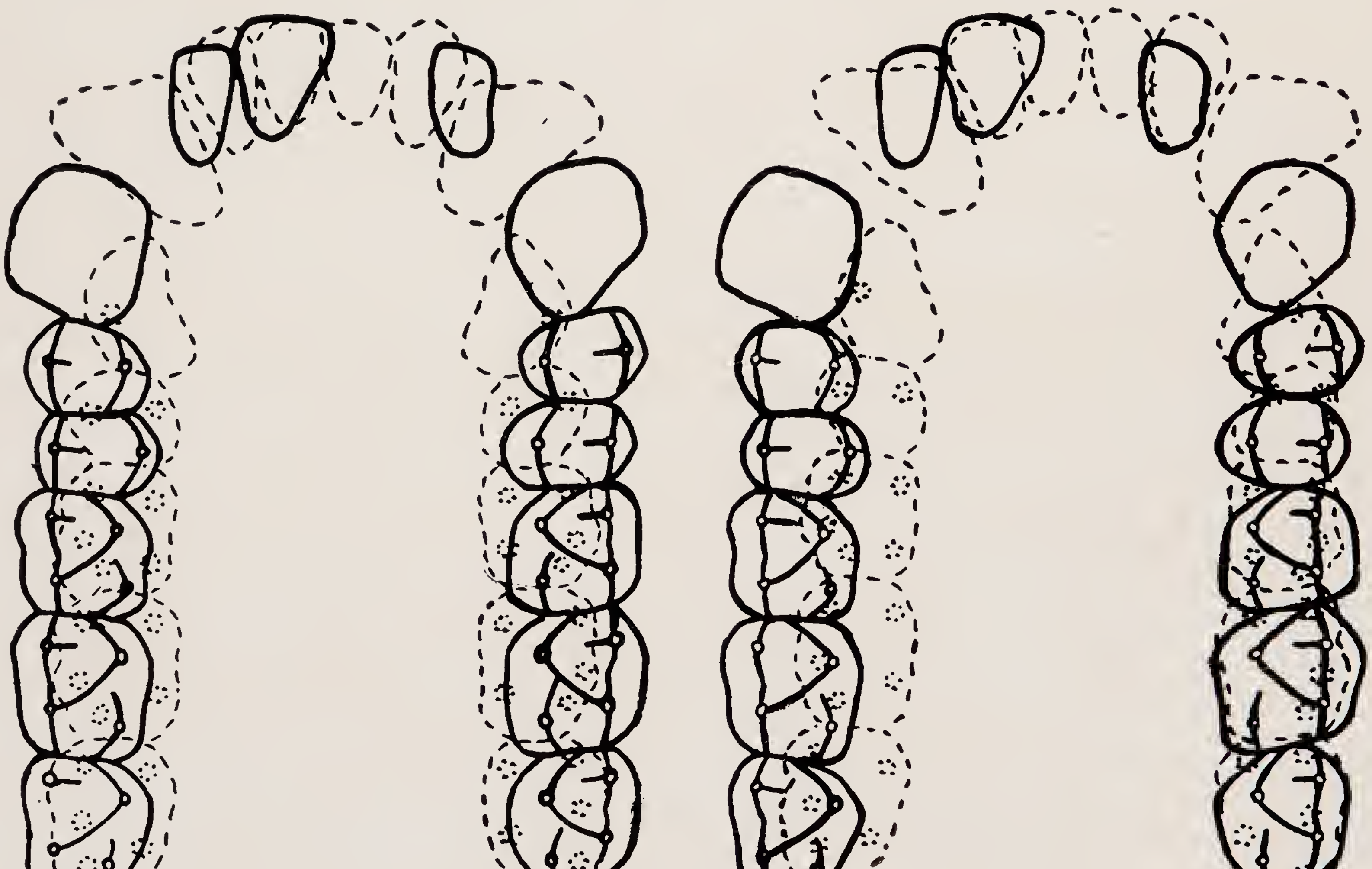
In *Fig.* 4 A we see how the two facets on the buccal side of the cusp are produced; by this cusp sliding down laterally between the two buccal cusps of the corresponding upper second molar. I have also included in this diagram the upper third and lower first molars, on which I have indicated the outlines of the resultant facets.



A

B

Fig. 5.—The upper and lower second molars of the *Gorilla*, superimposed; A, During the buccal phase of occlusion, and B, During the lingual phase, to show the areas of shear between the various cusps. The resulting facets are shown on the lower first and upper third molars.



A B

Fig. 6.—Plan view of the complete upper and lower dental arches of *Gorilla*, superimposed; A, In centric relation, and B, At the end of lateral excursion to the right.

Now this movement, as the lower cusps slide down the grooves between the corresponding upper ones, corresponds to rotation of the mandible about a point within the condyle of the same side; which we may call the ipsilateral condyle. As pointed out by McLean

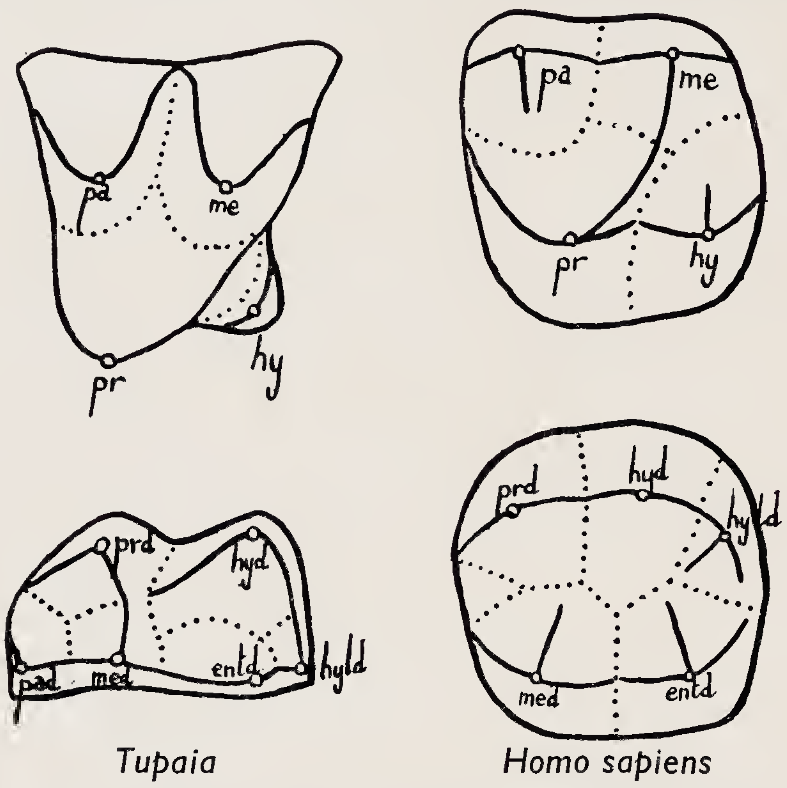


Fig. 7.—Upper and lower first molars of *Tupaia*, compared with those of man, to illustrate the nomenclature of the cusps.

(1938), this can be demonstrated by placing a pair of dividers with one point in the condylar fossa, when its other point can be made accurately to follow the paths of the cusps of the lower molars, along the grooves of the upper teeth, during chewing. I have called this the buccal phase of occlusion.

There is, however, a facet on the lingual face of this distobuccal cusp of the lower molar. This is indicated by shading with broken lines. On it the scratch marks run anterolingually rather than directly lingually; in fact in the same direction as the broken lines which form the shading. This facet is produced by the cusp shearing against the mesiolingual cusp, or protocone, of the corresponding upper molar, when the mandible rotates about the opposite, or contralateral, condyle. The manner of production of this facet is shown in *Fig.* 4 C. I have called this part of the chewing action the lingual phase of occlusion, and again the principle can be demonstrated by means of a pair of dividers.

If we now examine *Fig.* 5 we shall see that all the facets shown in *Fig.* 3 are accounted for by one of these two movements. All those which I have represented by continuous line shading, and on which the scratch marks run almost directly transversely, are produced by rotation about the ipsilateral condyle, as shown in *Fig.* 5 A. All those represented by

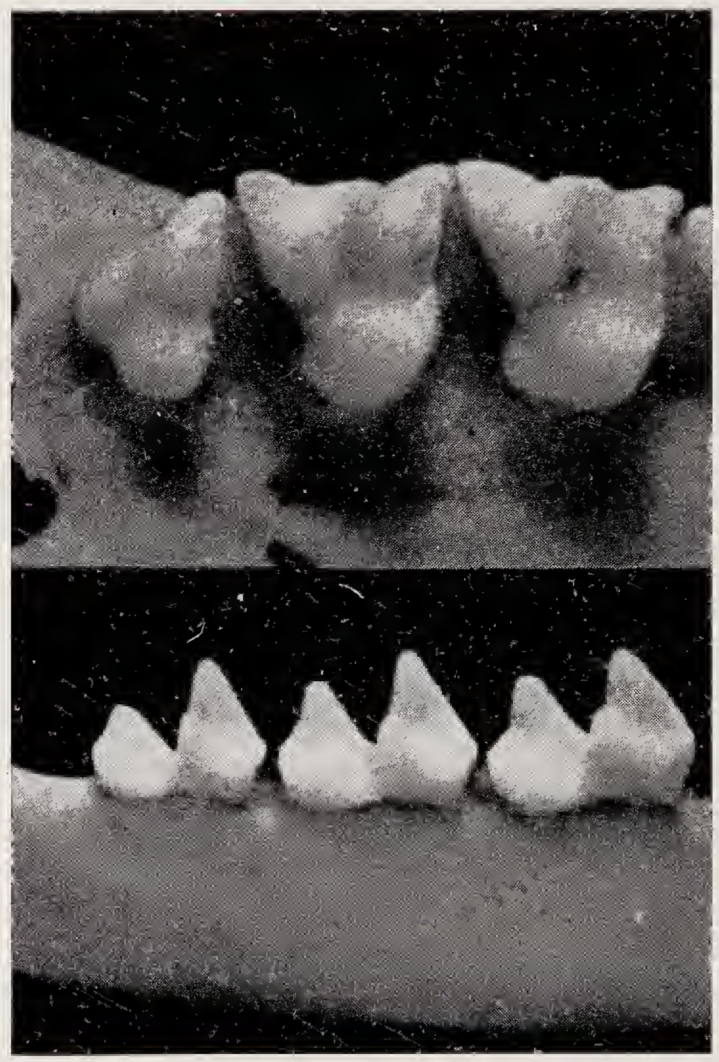


Fig. 8.—Oblique view of the upper and lower molar teeth of *Tupaia* seen from a position lingually and above the ocelusal surfaces.

shading with broken lines, and on which the scratch marks run somewhat anterolingually, are produced by rotation about the contralateral condyle, as in *Fig.* 5 B. I have been completely unable to find any facets which did not fit into one or other of these pictures, and, in fact, movement in any other direction is virtually impossible, because of the large canines.

Fig. 6 has been produced by first making accurate scale drawings of upper and lower dental arches of the gorilla. These have then been superimposed, on the left in centric relation, and on the right in right lateral excursion; that is, after rotation of the mandible about a point within the right condyle. The outlines of the lower teeth are shown by means of a broken, and the upper teeth by a continuous, line. It will be seen

that in the centric position each cusp rests in a groove or fossa in the opposing tooth. In lateral excursion, the lower cusps on the ipsilateral side have moved down the grooves between the corresponding upper cusps, producing a scissors-like, cusp-in-groove shear. This would serve to cut up the more fibrous articles of the diet—leaves and fruit, perhaps. On the contralateral side we have my "lingual phase" of occlusion taking place, and consequently producing a balanced occlusion. The mechanism is, however, rather different. The cusps of the lower teeth, instead of sliding between two upper ones, now move so that the plane lingual face of the lower buccal cusp shears against the buccal face of the upper lingual cusp. This produces a more horizontal type of shear, rather like a millstone, and perhaps intended for crushing and pulverizing the more brittle items of the diet, such as the bodies of insects.

To summarize, therefore, we have two phases of occlusion, the buccal, corresponding to rotation of the mandible about a point within the ipsilateral condyle, passing through the centric position, into the lingual phase, which corresponds to rotation about a point within the contralateral condyle. Moreover, the two phases take place simultaneously on opposite sides of the mouth, producing a balancing occlusion.

So much, then, for the gorilla, an advanced primate, whose large size makes it relatively easy to examine, but which should, more properly, lie at the end of our story. Let us now turn our attention to the other end of the scale, to the most primitive of the Primates, the tree-shrew, *Tupaia*.

This is a small, somewhat squirrel-like animal, found in the jungles of the Malayan archipelago. Its position is not above controversy, since many authors class it among the insectivores. However, even these agree that it is closely related to the Primates, Gregory (1934, b) describing this family as a " 'living fossil' group surviving from the Paleocene and Lower Eocene, which reveals to us the initial stage in the adaptations of the Primates". Simpson (1945) places it firmly in the Primate order.

Its molar teeth are particularly interesting, since they represent a persistence of an early stage in the development of all modern mammalian teeth—the so-called dilambdodont stage. Each upper molar consists essentially of a simple triangle or trigon. There is a single large lingual cusp, corresponding to the mesiolingual cusp in man, and known in the

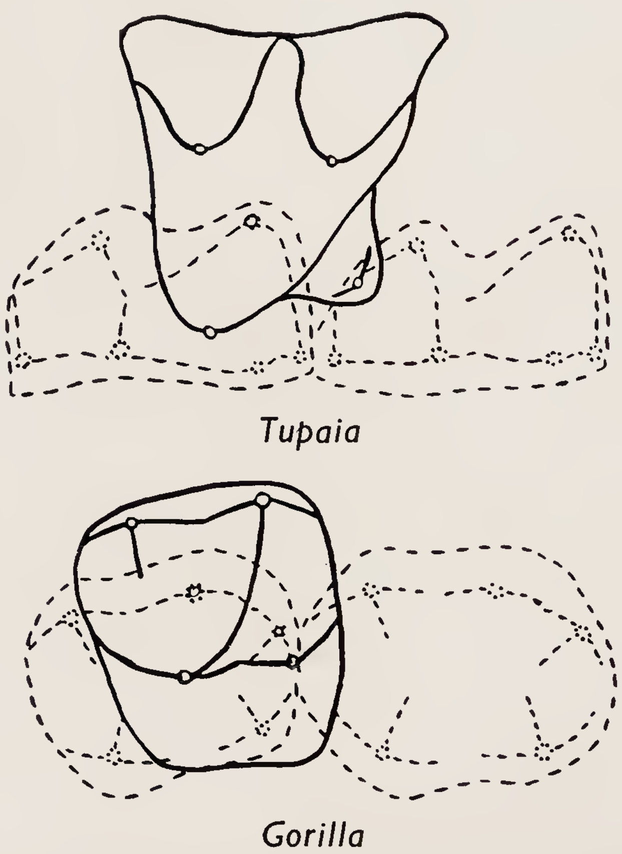


Fig. 9.—The upper first molar of *Tupaia* shown in centric occlusion with the first and second lower molars. A similar picture of *Gorilla* is shown for comparison.

terminology of Osborn (1888) as the protocone. This can be seen in *Figs.* 7, 8. About half way to the buccal margin are two further cusps, the paracone and metacone, corresponding to the mesiobuccal and distobuccal cusps in man. On the extreme buccal edge are three small cusps, or 'styles', which have no counterpart in the human dentition. They are joined to the paracone and metacone by a W-shaped series of ridges. At the base of the trigon, at a considerably lower level than these three cusps, and on the posterolingual face, is a very small cusp. This is called the hypocone, and develops to form the distolingual cusp in man.

The lower molars have two distinct parts. There is a high trigonid, rather similar to the trigon of the upper molars, but reversed buccolingually. There is also a lower heel, or talonid. The trigonid carries three cusps; buccally is

the protoconid, which corresponds to our mesiobuccal cusp. Lingually it has two cusps; the paraconid, which has disappeared in the human dentition, is the more anterior, while posteriorly the metaconid corresponds to our mesiolingual cusp. There are also three cusps on the talonid; the hypoconid buccally, and

Fig. 10.—Upper and lower dental arches of *Tupaia*, superimposed; A, In centric relation; B, At the end of lateral excursion to the right.

the entoconid and hypoconulid lingually. These correspond to the distobuccal, distolingual, and distal cusps respectively in man. It will be noted that the last of these has migrated from a lingual position in *Tupaia* to a buccal one in man. The above is essentially a description of the first upper and lower molars, but the remaining two differ only in details. The upper and lower dental arches are seen in plan view in *Fig.* 10.

In occlusion we have essentially the arrangement of reversed triangles which is the basis of the primitive mammalian dentition, as shown in *Fig.* 11. The upper trigon fits between the two lower trigonids, and occludes with the lower talonid. Thus the protocone fits into the centre of the talonid basin, and the hypoconid into the centre of the trigon, between the paracone and metacone. This is a very basic mammalian arrangement which is also seen in our own occlusion: indeed, in some ways it is a better criterion of normality than Angle's. In the same way, the trigonid of the lower molar fits between two upper trigons, although in this case there is nothing corresponding to the talonid of the lower tooth, with which it can occlude; the hypocone is too rudimentary to be of much importance at this stage.

Most authorities consider that chewing, here again, consists of a vertical champing action, but this is not strictly so. In fact, the

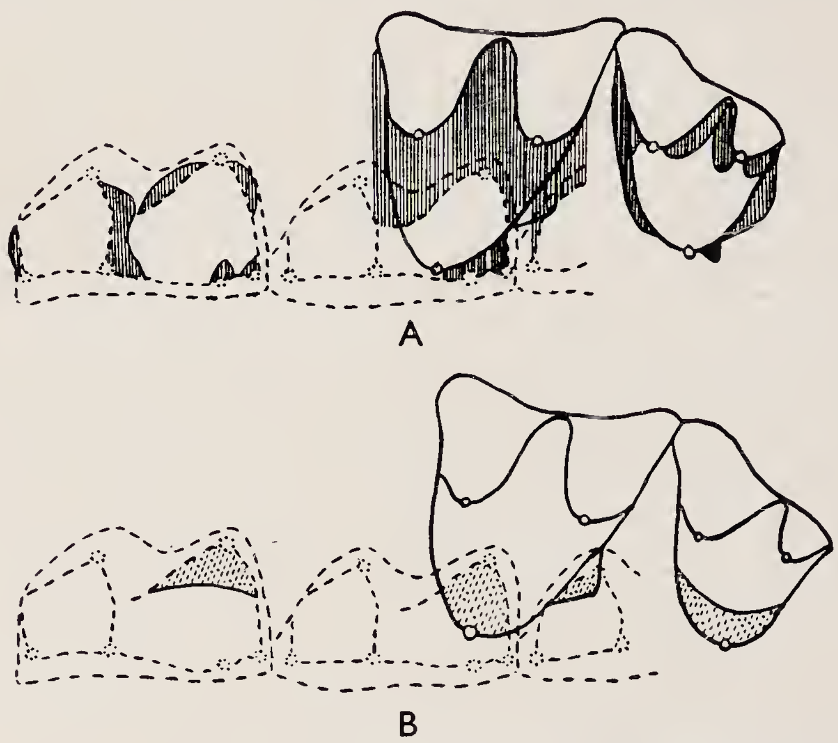


Fig. 11.—The upper and lower second molars of *Tupaia*, superimposed; A, During the buccal phase of occlusion; B, During the lingual phase, to show the areas of shear between the various cusps. The resulting facets are shown on the lower first and upper third molars.

basic principle is the same as that seen in the gorilla. During rotation about the ipsilateral condyle, the lower cusps pass between the corresponding upper ones, as seen on the right side in *Fig.* 10 B. At the same time, on the other side of the mouth, the lower buccal cusps are shearing across the upper lingual ones, rotation being about the contralateral condyle. This also produces a series of facets, as shown in *Fig.* 11. In *Fig.* 11 A we see the upper right second and third molars, shown by a continuous outline, and the lower first and second by a broken outline. The areas of contact between the teeth, during the buccal phase of occlusion, are shown by the continuous shading on the second molars, while the resulting facets are shown on the upper third and lower first molars. In the same way we can follow the production of the facets during the lingual phase of occlusion—that is, during rotation about the opposite condyle—in *Fig.* 11 B. It

will be seen from the second molar occlusion that a very slight contact is produced by shear of the lower protoconid across the diminutive hypocone. The resultant facets cannot be clearly shown, since there is no hypocone on the third upper molar, while the protoconid of the first lower molar is

In general we find the same picture as in *Tupaia* and *Gorilla*; that is, of two phases of occlusion, the one corresponding to rotation about the condyle of the same side, and the other corresponding to rotation about the opposite condyle. Moreover, there is a balanced occlusion in each case. Consequently,

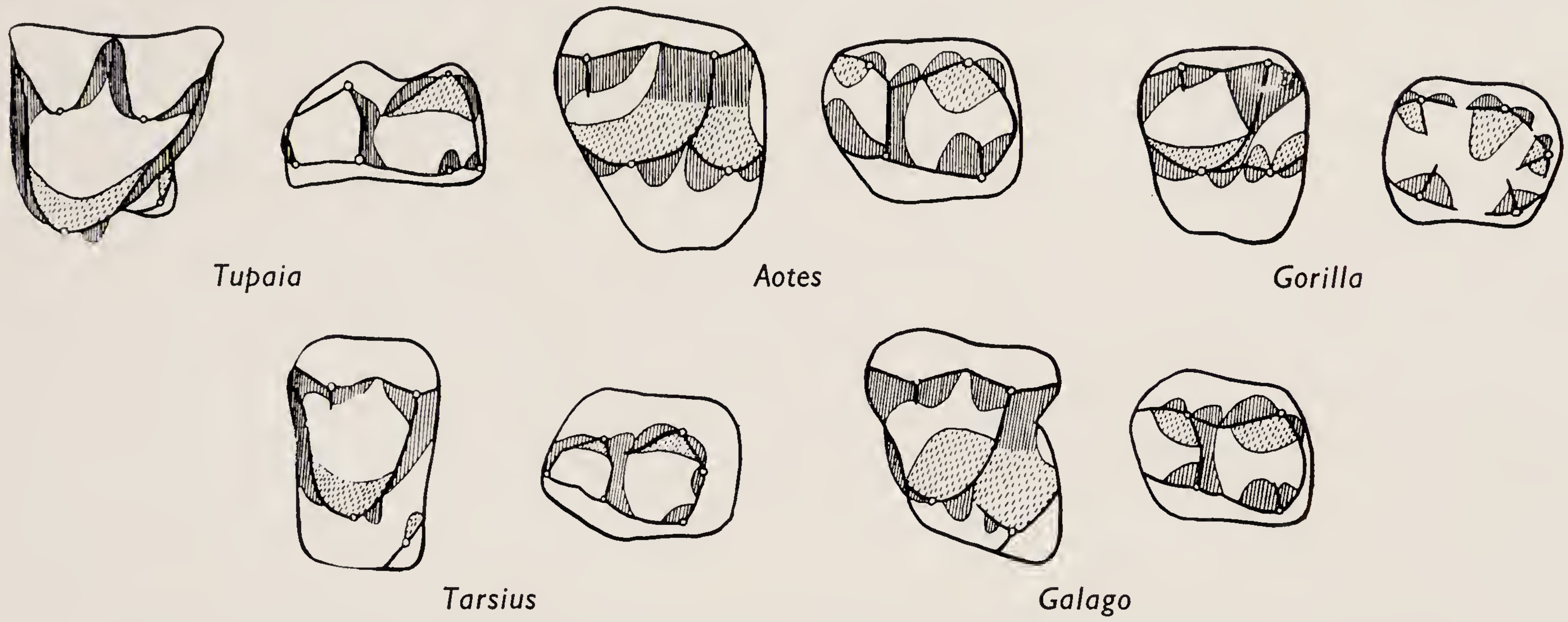


Fig. 12.—Plan of upper and lower first molars of representative genera of Primates, showing the pattern of wear facets found on these teeth.

functionless during the lingual phase of occlusion; it cannot shear across the hypocone of a premolar, since such a cusp does not exist in this genus.

So here again we have the two phases of occlusion, corresponding to rotation about the two opposite condyles. Again they occur on the two sides simultaneously, producing a balancing occlusion, as shown in *Fig.* 10 B. In fact, the picture is essentially similar to that seen in the much more advanced gorilla. Since the cusps of *Tupaia* are much sharper than those of *Gorilla*, the path of movement of the cusps is very steep in *Tupaia*, and nearly horizontal in *Gorilla*, but this is a difference of degree only, and not of principle.

I have examined and made detailed drawings of representatives of every family and subfamily of the Primates, with the exception of *Daubentonia*—the aye-aye of Madagascar—in which the dentition is highly specialized and the molars degenerate. I have also made less detailed examination of every genus represented in the British Museum (Natural History) to eliminate the possibility of aberrant genera.

as one would expect, the facet pattern is essentially the same in each case. I have shown this in *Fig.* 12, for certain representative genera, *Tupaia*, with which we have already dealt, is the most primitive of all the primates. *Tarsius*, the spectal tarsier of Borneo, is the sole survivor of a group of Primates which is allied to the lemurs, and which was widespread in the Eocene era. The molars are slightly advanced beyond those of *Tupaia*, with the cusps considerably blunter. The external row of 'styles' is virtually eliminated on the upper molars, while the hypocone is somewhat larger, and shears against the protoconid of the lower molar during the lingual phase of occlusion. On the lower molar the paraconid and hypoconulid have both migrated somewhat buccally, while the trigonid is less raised above the talonid. The facet pattern, however, remains essentially the same.

Galago, the bush baby of East and West Africa, is a true lemur. It shows considerable advances over the condition seen in the tarsier. The hypocone has become a very large, functional cusp, still shearing against the protoconid of the succeeding lower tooth,

during the lingual phase of occlusion, and also shearing, to a slight extent, against the posterobuccal face of the entoconid during the buccal phase. Both the paraconid and hypoconulid have disappeared completely, and the trigonid of the lower molar is only slightly raised above the talonid. *Aotes* is a member of the New

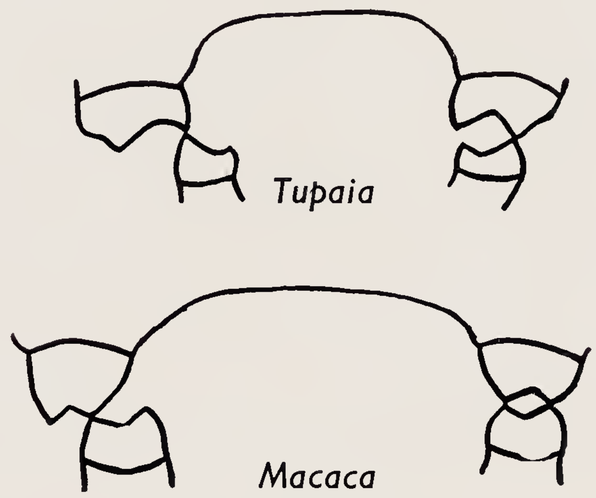


Fig. 13.—Cross-section through the centre of the first molars of *Tupaia* and *Macaca*, at the end of lateral excursion to the right.

World monkeys, found in Central and South America. The picture is essentially the same as that seen in *Galago*, with a large hypocone producing a quadricuspid upper molar, and functioning primarily during the lingual phase of occlusion. However, a new facet has appeared on its posterolingual face, corresponding to one on the anterobuccal of the metaconid of the next succeeding lower molar, and produced during the buccal phase of occlusion. So this cusp now comes to play an important part in both phases of occlusion.

Finally we come to the picture seen in *Gorilla*, which I have already described. The main difference here is that we once again encounter the hypoconulid, which was absent in *Galago* and *Aotes*. It will be observed that the general pattern of the facets remains remarkably constant in all these widely differing members of the primate order, as, consequently, does the pattern of occlusion. This is not, of course, a phylogenetic series; all these genera are still in existence, although this pattern of facets has been identified in a limited amount of fossil material. Nevertheless, they represent stages through which it is believed that man himself went, during his evolution.

I have not, so far, mentioned the Old World monkeys, from Asia and Africa; the ordinary monkeys, seen in large numbers in zoological gardens, and of which one member, the macaque, is a popular experimental animal. Here we find a slight difference from that seen in the other primates. The buccal phase

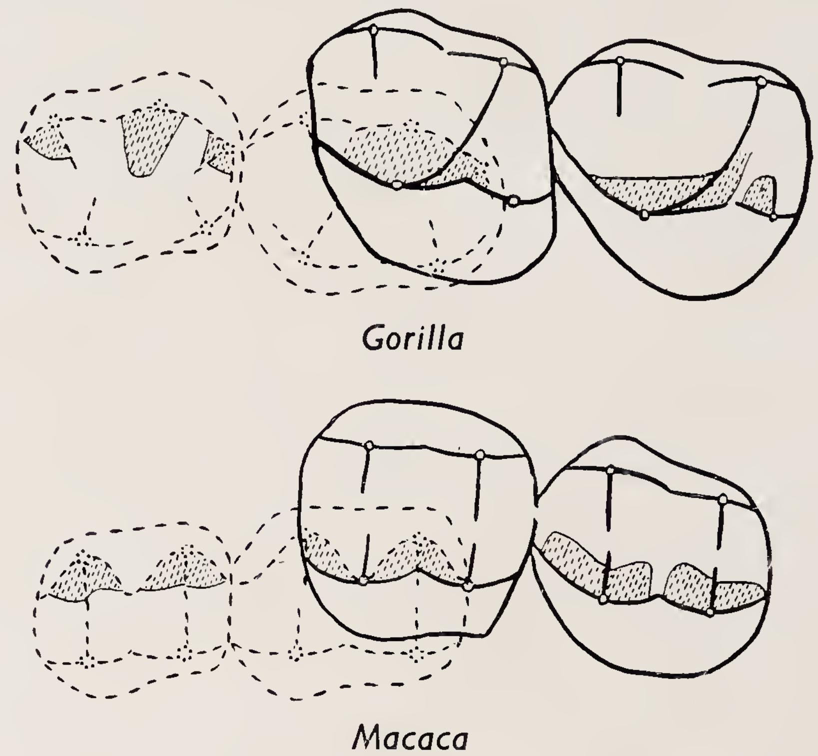


Fig. 14.—Upper and lower second molars of *Gorilla* and *Macaca* superimposed during the lingual phase of occlusion, to show the areas of shear between the cusps. The resultant facets are shown on the lower first and upper third molars.

of occlusion differs but little from that seen already, with the cusps of the lower molars passing in the grooves between the cusps of the upper molars. The only way in which the Old World mokeys differ from the majority of Primates during this phase of occlusion is in the increased importance of the lingual cusps. In the majority of families the lingual cusps of the lower molars are considerably lower than are the buccal ones. This means that in the buccal phase of occlusion contact of the lingual cusps is lost considerably before that of the buccal cusps. This is shown in *Fig.* 13, on the right side of diagram, for *Tupaia*. In the case of the Old World monkeys, on the other hand, the height of the lingual cusps is considerably increased, relative to the buccal ones, so that contact of the former is continued until the end of the buccal phase. This is again shown in *Fig.* 13, and, of course, considerably increases the efficiency of the mechanism.

There is a rather more noticeable difference during the lingual phase of occlusion. Firstly the importance of this phase of occlusion is greatly reduced, and contact between the upper lingual and lower buccal cusps quickly lost, so that there is no proper balancing occlusion. Secondly the upper lingual cusps are displaced anteriorly, and the lower buccal ones posteriorly. The result of this can be seen in *Fig.* 14. In the gorilla we see the cuspal arrangement usual in the Primates during the lingual phase of occlusion. The lower buccal cusp slides up the buccal face of the upper lingual cusp, with the millstone type of shear, and produces a single facet on each cusp. In the Old World monkeys, on the other hand, due to these cuspal displacements, the lower buccal cusps slide between the upper lingual ones, reproducing the effect seen during the buccal phase, and producing two facets on each cusp. This means that we have the cusp-in-groove, scissors-like, type of shear during both phases of occlusion. It is thought that this is a modification to suit a diet of leaves, and it is widely found among other leaf and grass-eaters, as diverse as the sheep, tapir, and kangaroo. It is, however, more or less unique among the Primates.

It would seem, therefore, that in all the groups of Primates so far considered—that is, in all except man—the pattern of chewing is essentially the same, consisting of rotation of the mandible about the two condyles alternately, with occlusion on the two sides of the mouth balancing. As previously indicated, the large canines of the gorilla prevent any intermediate movements since, if such were attempted, the cusps of the posterior teeth would be driven out of contact. The canines are similarly enlarged in the Old World monkeys and in some families of the New World monkeys. Among the Prosimii—the lemurs and tarsiers—the canines are little or no larger than the premolars. In these genera, however, the cusps are much sharper and more pointed than in the higher primates, and intermediate positions, which would produce a cusp-to-cusp relation during the buccal phase of occlusion, would be impracticable. Moreover, a careful scrutiny of the scratch marks on the molar teeth has failed to show any whose production could be accounted for by jaw movements in any other direction, although a large number are seen which result from this bilateral rotary movement. It may be noted that in the New World monkeys, large canines are in general found in those species whose cusps are relatively blunt, and small ones where the cusps are higher and sharper.

Now since this chewing mechanism is so universally found among the other primates, it would seem possible that it might also apply to man. The teeth of mammals generally are closely adapted to the mode of chewing, and there are only minor differences between the teeth of the gorilla and those of man. On the other hand, the canines in the permanent human dentition are reduced to the status of a third incisor, and are no longer interlocking (although they show a more ape-like arrangement in the deciduous dentition). Consequently, since the cusps are quite blunt, a range of intermediate movements is quite possible, and Gregory (1916) contrasts the lateral slide of the jaw in the gorilla with what he describes as a rotary movement in man.

I do not altogether agree with this, but would suggest that the same pattern of chewing is normal for man as for the other primates.

It is surprisingly difficult to collect a number of human skulls which exhibit good occlusion, with a more or less full complement of teeth, and in which the cusps are not unduly worn. In the large collection of skulls in the Manchester Museum I was only able to find one. Consequently, my examination has been limited to five skulls, all of which exhibited normal occlusion, and such that the wear of the molar teeth had not exposed the dentine. There was no reason to think that their chewing action, during life, would have been in any way abnormal.

In these skulls the pattern of the wear facets is essentially the same as that seen in the gorilla, although it may not be possible to identify each separate facet in each specimen. In *Fig.* 15 we have the facet pattern for one skull, compared with that for the gorilla. It will be seen that they are essentially

alike, and that, here again, we have two sets of facets, one corresponding to rotation about the ipsilateral condyle and the other to rotation about the contralateral condyle. The scratch marks on the facets also show a high degree of parallelism nearly, if not quite, as marked as in the lower primates. It would seem, therefore, that the majority of wear is caused, and therefore the majority of chewing carried out, by this bicondylar rotary movement.

To digress slightly; I examined one skull which did not seem to fit into this picture. On two of the teeth, both premolars, were well-marked facets bearing scratch-marks which ran in an anteroposterior direction. This was somewhat disturbing, since I had been at considerable pains to exclude the possibility of such jaw movements in other primates. Bennejeant (1936) claims that it occurs in the Old World monkeys, but a close scrutiny had failed to find any evidence of it. However, the solution proved to be that these two teeth had been fitted to the skull posthumously, to replace two which had been lost. The facets had been produced artificially, by filing the teeth to restore the occlusion.

This theory of occlusion, as told by the wear facets on the molar teeth, has a number of applications, particularly in palaeontology. The teeth being hard and indestructible, they are frequently the only part of a fossil species which is known to us. From an examination of the cusp forms and the wear facets thereon it is possible not only to reconstruct the form of the opposing teeth, but also to tell some of the habits of the animal concerned and its relationship to other fossil or living forms.

It also has certain applications to the human dentition, and in particular it helps to explain the purpose of the eminentia articularis.

The articular eminence is, as Gregory and Hellman (1940) point out, a peculiarly human character, found only in man and the South African fossil ape-men or Australopithecines. In the great apes, however, the corresponding area of the articular fossa slopes downwards anteriorly, to the root of the zygoma. The human ementia is apparently an extension of this arrangement. In the monkeys and lemurs on the other hand, the anterior part of the glenoid fossa is more or less parallel to the occlusal plane; in the *Galagos* or bush-babies it even slopes upwards anteriorly.

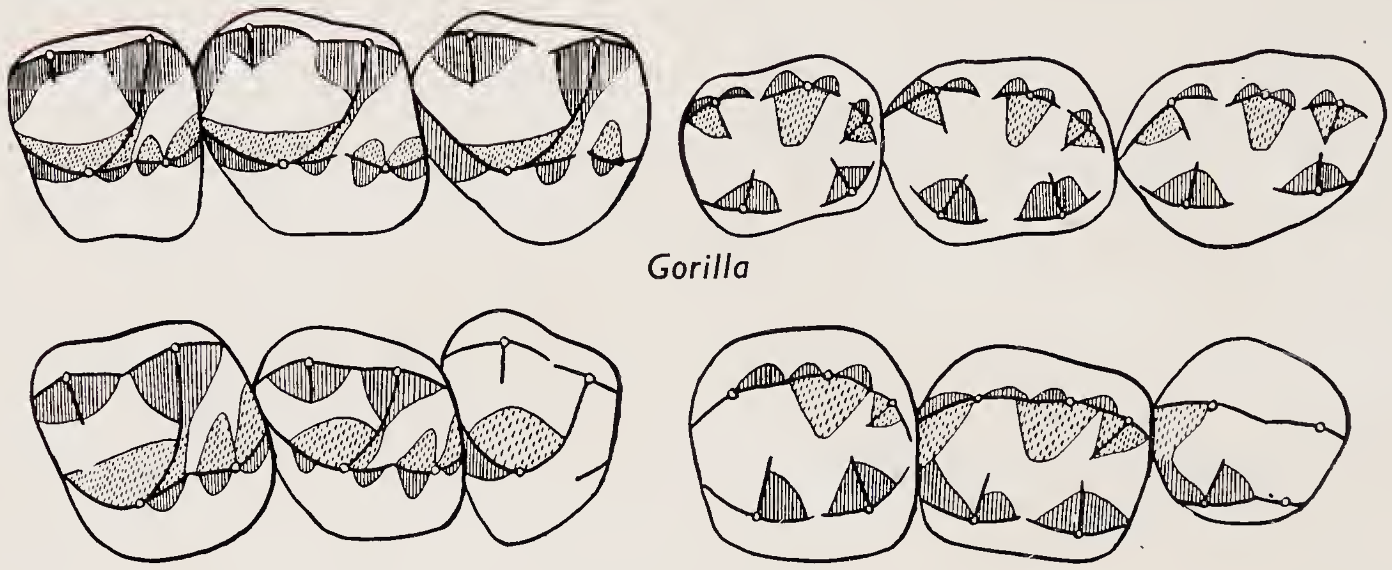


Fig. 15.—The pattern of wear facets found in the *Gorilla*, compared with those found on one human skull.

The above authors consider that the purpose of the eminentia is to allow the incisors to "clear" their opponents during lateral movements, while many odontologists consider that it is a device to allow the incisor teeth to be used independently of the chewing teeth, in a manner analogous to that seen in the rodents. Indeed Reisner (1938) attempts to correlate the steepness of the slope of the eminentia with the degree of overbite. Neither of these arguments is convincing, for three reasons:—

1. In transferring the function from the molars to the incisors, the same effect could be produced by a horizontal forward translation, combined with a hinge-like opening movement of the mandible.

2. During lateral movement in an animal such as the gorilla, which normally has an edge-to-edge occlusion of the incisors, the teeth lose contact and open quite widely; the same is also true of the human dentition if an edge-to-edge relation of the incisors is present. This is, of course, due to the height of the cusps, which causes the so-called lateral movement to be, in fact, a lateral and downwards movement. Consequently there would be sufficient space to accommodate a normal degree of overbite of the incisor teeth.

3. Both the explanations so far advanced depend upon the positive overbite which is often present in man, and seldom so in other primates. But Hellman (1920) points out that this is essentially a development of the last 1,000 years, while the articular eminence has been present ever since the human line began to differentiate. Moreover the same author (1918) has shown that a positive overbite is present in about 30 per cent of orang outangs, where there is no articular eminence.

Let us now consider what happens during lateral excursion. The mandible rotates about a point within one condyle, while the other condyle moves forwards and downwards on to the eminentia. That is, the one condyle descends to a lower level than the other. This must produce a lateral tilting of the mandible. Moreover it is difficult to see how this could be produced by any other means; it is difficult to visualize an efficient joint in which the articular surfaces part company.

Now if we examine the human molar teeth, it is noticeable that the upper molars lean somewhat buccally and the lowers lingually. This is different from the situation seen in all other primates; in the great apes they are approximately vertical, while in the lower primates the upper molars lean lingually and the lowers buccally.

The result of this can be seen in *Fig.* 16. This was prepared by selecting specimens of the genera *Lemur*, *Gorilla*, and *Homo* which exhibited good unworn dentitions. I then took impressions of their upper and lower dental arches, in a hydrocolloid impression material, and prepared models in stone-hard plaster-of-Paris. The lower model was carefully sectioned at the level of the hypoconid of the lower first permanent molar, using an orthodontic model-trimmer. The casts were then articulated in centric relation, and the upper model sectioned at the same level. Accurate photographs were then taken of the cut surfaces, and the line drawings shown in

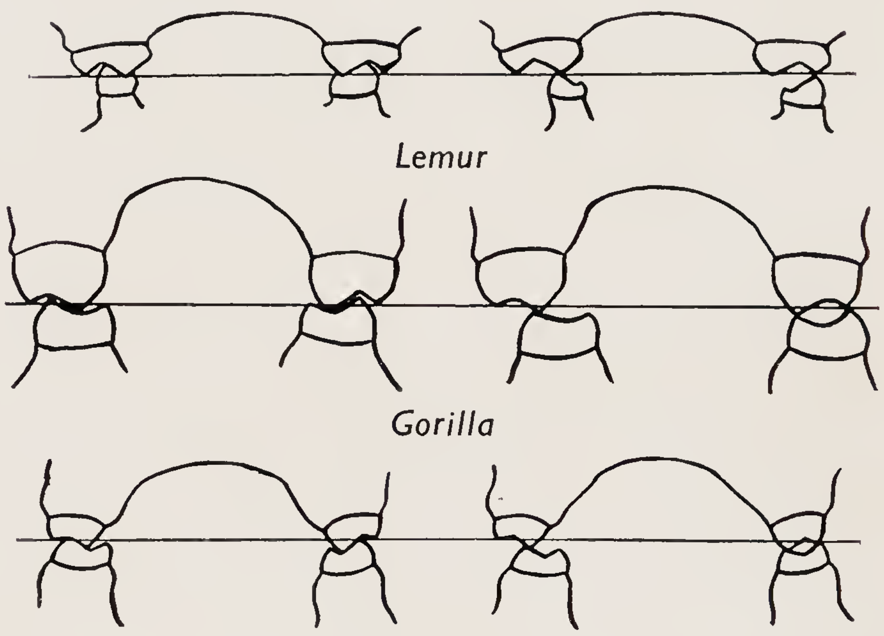


Fig. 16.—Cross-section through the first molars of *Lemur*, *Gorilla*, and *Homo sapiens*, at the level of the hypoconid of the lower first molar. Shown on the left in centric relation, and on the right at the end of lateral excursion to the right.

Fig. 16 produced by tracing from these photographs. It is important to realize that, whereas this section goes through the tip of the upper lingual cusp, on the buccal side it goes not through a cusp, but directly through the deepest part of the groove between the two buccal cusps. Similarly in the lower jaw, it goes through the tip of the buccal cusp, but through the lingual groove.

On the left side, in this figure, the upper and lower first molars of the three genera are therefore seen in centric relation. On the right they are shown in right lateral excursion, seen from behind, so that the teeth on the right of the diagram are in the buccal phase of occlusion, the tip of the hypoconid of the lower tooth having just completed its movement down the groove between the two upper buccal cusps. Those on the opposite side of the mouth are similarly at the end of the lingual phase of occlusion. Since this consists of a cusp-to-cusp shear, unlike the cusp-in-groove shear seen during the buccal phase, the tip of the

hypoconid of the lower molar is resting on the tip of the protocone of the upper molar.

In the case of *Lemur* the tip of the protocone and the lowest point of the groove between paracone and metacone are at the same vertical level; they are both just touching the horizontal base line which I have drawn. Therefore, as the tip of the hypoconid moves down the groove between the two buccal cusps on the right side of the mouth, so the tip of the same cusp on the opposite side of the mouth follows a parallel course down the buccal face of the protocone of the upper tooth. They finish at the same level and no tilting of the mandible is necessary.

In the case of the gorilla, on the other hand, the tip of the protocone hangs below the base line, which joins the lowest point of the buccal groove on each side. In lateral excursion to the right, therefore, as the hypoconid of the right lower molar moves down this groove, the same cusp of the tooth on the opposite side of the mouth has to move down to the tip of the protocone of the upper molar; that is, to a lower level than its fellow of the opposite side. To facilitate this the mandible has to tilt, and the anterior part of the glenoid fossa therefore slopes downwards to the root of the zygoma. This effect is even more marked in man, and to achieve the requisite degree of tilt an eminentia articularis becomes necessary.

To some extent the above is a statement of the obvious; if there is tilting of the mandible due to the condylar arrangement, and the teeth are to remain in contact bilaterally, the latter must be arranged in the manner which I have described. On the other hand, the converse is also true. I have not shown if there is a cause-and-effect relation, nor, if so, in which direction it operates.

Fig. 17.—Bases of skulls of *Lemur*, *Gorilla*, and *Homo sapiens* reduced to the same width, to illustrate the gradual reduction of facial prognathism.

Fig. 17 shows the bases of the skulls of the same three animals—*Lemur*, *Gorilla*, and man. It will be observed that in the lemur the condylar fossæ lie almost directly behind the molar teeth, and considerably posterior to them. In the gorilla there is a considerable reduction in facial prognathism, and consequently the fossæ are displaced laterally relative to the teeth, while the latter are, of course, nearer to the condyles. In man, again, this effect is further accentuated. Consequently the tapering mandible of *Lemur* lies well within the upper arch, and if the molar teeth are to occlude, the upper ones

must lean lingually and the lower ones buccally. As a result, the tips of the upper buccal cusps lie at a lower level than those of the lingual cusps. The reverse is true in the lower arch.

Now in the case of man, with the jaws drawn back under the cranium, the mandibular base lies well outside the base of the maxillary arch, since the condyles are displaced relatively laterally. As a result the upper molars must lean outwards and the lowers inwards if they are to occlude. The condition in the gorilla is intermediate between these two extremes. In man, therefore, the tip of the protocone is considerably lower than the lowest point of the sulcus between the two buccal cusps. If the teeth are to remain in contact during lateral excursion, the mandible must tilt, and an eminentia articularis becomes necessary.

SUMMARY AND CONCLUSIONS

1. There is a common pattern of chewing throughout the Primates, including man.

2. This consists essentially of two phases. The one, corresponding to rotation of the mandible about a point within the condyle of the same side, is here called the buccal phase. In it the lower buccal cusps slide in the grooves between the upper buccal ones, and similarly the lower lingual cusps slide between the upper lingual ones.

3. This passes through the centric position, into the lingual phase of occlusion, which corresponds to rotation about a point within the opposite condyle. Here the lower buccal cusps normally slide down the buccal face of the upper lingual cusps, although there are differences of detail in the Old World monkeys.

4. The two phases of occlusion occur simultaneously on opposite sides of the mouth, thus producing a balanced occlusion.

5. In man, owing to the narrowness of the upper dental base compared with the lower, the upper molars lean buccally and the lowers lingually. This is the reverse of the situation seen among the lower Primates. In order that the teeth on both sides of the mouth shall remain in contact during lateral excursion, it is necessary for the mandible to tilt laterally.

6. The eminentia articularis is a device to enable this to take place.

Acknowledgements.—I wish to express my thanks to Professors H. G. Radden and E. Matthews for the facilities they have given me, and for their encouragement and advice. To Dr. T. C. S. Morrison-Scott and his colleagues at the British Museum (Natural History) for access to, and loans of specimens, particularly that shown in *Fig.* 9. To Mr. R. U. Sayce and his colleagues of the Manchester Museum, again for the loan of specimens, especially those shown in *Figs.* 1, 2, and 18. And to the Department of Medical Illustration, United Manchester Hospitals, for the preparation of photographs and lantern slides.

I would particularly thank Dr. P. M. Butler, of Manchester University, for his constant assistance and advice.

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DISCUSSION

Mr. Chapman, from the chair, thanked Mr. Mills for his paper and noticed that he had quoted from D. M. Shaw, who had been attached to the Royal Dental Hospital, but thought that not many of the meeting would remember him. He wrote a number of articles prior to the first world war, including "The Bearing of a Theory of Maximum Shear on the Mechanism of Mastication in Man" (1915) *Dent. Cosmos*, **57**, 465. He thought he had read a communication to the B.S.S.O. He was sure that Shaw would have been pleased to hear his work referred to. Mr. Chapman mentioned some of the classical theories concerning the articular eminence and the overbite. He felt that students of to-day were missing something in not having to learn the amount of comparative dental anatomy that was taught fifty years ago.

Dr. Burston in opening the discussion said that he was sure that the audience had all listened with great interest to this elegant analysis of the functional adaptations existing in the masticatory apparatus of the Primates. He for one, greatly welcomed this return to the morphological method, which he felt had, with a few notable exceptions, been relatively neglected during the last decade. He suggested that orthodontists had perhaps been somewhat overconcerned with *ad hoc* investigations aimed at the solution of some particular clinical problem. In their desire to produce diagnostic criteria for the appraisal of such problems they had introduced their own peculiar nomenclature and in an attempt to invest these qualitative terms with precise meaning, had often indulged in a host of geometrical and mathematical abstractions, mostly in the guise of cephalometrics.

Whatever the ultimate value of this approach might be, he felt that in the present state of knowledge it is unlikely to take us very far in the appreciation of the skull and masticatory apparatus as a functional, coordinated unit at all stages of development. So very little is known of the vital processes operating at the cellular level, of why a bone grows to a certain size and shape, or why a tooth assumes a certain form, of how a muscle functions or how the neural system operates, that it seems almost presumptuous to contain these mysteries within a mathematical formula based on a few arbitrary measurements and even the most refined methods known to physiology appear crude when considered in relation to this problem. The morphological approach seeks rather to find functional correlations existing in a living organism and here he used the word "functional" in its widest connotation as including all the vital processes taking place in the body, the integration of which leads to form as we know it. It does not presume to explain such findings in terms of final causes—rather does it use teleology as a regulative principle. The interplay of form and functional adaptation is a problem that has excited the interest of great thinkers down the ages and orthodontists were privileged, as perhaps few others, to witness the interplay of these factors in their daily work. It is this functional adaptiveness of parts which is, as he thought, at the real centre of the orthodontic problem. Such an approach has the authority of antiquity and it was therefore in the true Cuvevian tradition that he welcomed this contribution of Mr. Mills; another stone added to the cairn of morphological knowledge which will eventually lead, he felt, to a truer understanding and sympathy for that complex and beautifully integrated piece of architecture—the skull and masticatory apparatus.

Turning now to some of the detailed points raised in the paper, he was particularly interested in Mr. Mills's analysis of the buccal and lingual phases of occlusion and the two distinctive parts each had to play in efficient mastication.

The meticulous accuracy of his observations and the logical force of his arguments command acceptance in so far as they apply to those Primates exhibiting idealized occlusion and in which the mandibular movements are constrained by the limitations imposed by the large and interdigitating canines to a narrow path.

However in the extension of these principles to man, he thought that caution was necessary because there are not the limitations imposed by large canines. He was prepared to accept that in a young adult, having relatively unworn molars such is in fact the case—he recently witnessed a film of cine-radiography of the condyle which, in retrospect, appeared to support this contention. However he wondered whether this is always true in older patients exhibiting true cusp attrition. He was aware that it is now suggested that a conditioned muscular behaviour operates under the influence of a possibly inherited neurological pattern. On a broader level the concept of individual chewing habits has received certain acceptance. On the present evidence it would appear that the cusps dictate the chewing habits of man, but when these are worn or lost does the neuromuscular unit perpetuate this action? In disturbances to the occlusion, such as is produced by drifting of teeth following extraction, or more dramatic events leading to faulty tooth position such as trauma, it is remarkable how the muscle action adapts, in many cases, to the new environment. Is it not then possible that with occlusal wear in man, and with no large canines to restrict the chewing action, this increased freedom may lead to the adoption of movements other than the bicondylar rotation suggested? Marked occlusal wear is a feature of most primitive dentitions and even in civilized man cuspal attrition often proceeds to a marked degree. As against this, in recently edentulous patients the gothic arch tracing obtained in prosthetic procedures appears to support the principle of bicondylar rotation and lends strength to the view that this is indeed the fundamental pattern.

Further to the question of mandibular movement, he would be interested to learn whether Mr. Mills observed any lateral translation of both condyles in the Bennett movement. He did not incline to this possibility himself, but would be grateful for Mr. Mills's view on the matter.

He was also most interested in Mr. Mills's hypothesis with reference to the functional correlation proposed between the eminentia articularis and the lateral inclination of the buccal teeth. He recently had the opportunity of examining the skulls of different races and was impressed by the almost vertical inclination of the teeth in certain dark races. Unfortunately he was not then aware of the possibility of this correlation and did not pay particular attention to the height of the eminentia, but as far as he recollected the eminentia was normally developed. Perhaps Mr. Mills would care to comment on this matter.

Returning to this question of cusp-in-groove and cusp-to-cusp occlusion, he was interested in the exception to the general rule provided by the Old World monkeys, particularly in view of their specialized diet. Is one to see in this a further justification for the Darwinian theory of evolution? He knew that *in sensuo stricto*

and, as a respectable scientist of this generation, one should accept but are we entirely happy? He often wondered!

Finally he rather understood Mr. Mills to place these Primates in some sort of sequence, as showing how these masticatory systems had evolved. He knew that Mr. Mills would not support this series as in any way a phylogenetic one, but he was interested in the order in which he placed them, having regard to the fact that some consider the higher primates as having a more advanced tooth form than that seen in man.

He thanked Mr. Mills for a most interesting and stimulating paper.

Mr. Glass asked Mr. Mills whether man's dentition was essentially more primitive than other primates? As man appeared to be the only mammal with contact points throughout upper and lower arches and considering the prevalence of interproximal caries, did he consider this continuity of contact points a retrograde step in our dental development, and what were his views on the introduction of artificial diastemata by extractions?

Professor Hallett thanked Mr. Mills for his excellent paper, which he had found most interesting. He said that he would like to ask Mr. Mills whether he had examined several specimens of each family in determining the attrition patterns, whether the often different canine length between the sexes had led to variations in faceting, and, finally, whether he had made any observations upon the deciduous dentitions?

Mr. Mills thanked Dr. Burston for his kind remarks about his paper. He wholeheartedly agreed with Dr. Burston's views on the importance of morphological, as opposed to statistical, research. The cusp nomenclature introduced by Osborn was, in nearly all ways, more convenient than that usually employed by the dental profession, but it seemed improbable, at this stage, that the profession could be persuaded to change its habits in this matter.

He had not investigated the effects of cusp attrition, but he felt that the normal pattern of chewing was the result of an inherent neuromuscular pattern. While this chewing action might be prevented in certain cases, notably by cuspal interference, there was a strong tendency to return to it as soon as this was possible. This was confirmed by the instinctive chewing motions seen in a child with a "locked bite", in a postural Class III malocclusion, when using articulating paper to trim the posterior bite plane on an orthodontic appliance.

He had been unable to find any evidence of any Bennett movement in the primates. In a few genera it was impossible, because of the shape of the glenoid fossæ. In the other genera he did not feel that his method was sufficiently accurate to eliminate the possibility altogether. It might be the result of individual variation.

While it was true that in some individuals, particularly among the more primitive races, the molars were approximately vertical, this meant that the upper buccal cusps were on the same level as the upper lingual ones, and the groove between the former, even at its lowest point, was still higher than the tip of the lingual cusp. It therefore did not invalidate his argument.

He realized that he had tended to interpret his series as though it were a phylogenetic one. This was not strictly justifiable, but there was evidence to show that man had, in his evolution, gone through stages in which his dentition was very similar to those seen in certain recent Primates.

In reply to Mr. Glass, he felt that it was an over-simplification to describe man's dentition as more primitive than that of the lower Primates. Many of the apparently primitive features of our dentition were, in fact, only secondarily so.

It was true that many mammalian genera had diastemas in their dentition, but these were invariably frank spaces, and where the teeth were in contact, a normal contact point existed. The "slack contact" was, he thought, unknown in natural dentition.

In reply to Professor Hallett, he had based his examinations of the dentitions on a number of specimens. He had not kept records of the exact numbers, but thought six would be the minimum for any genus. He had examined the deciduous teeth of some genera, as a matter of interest, and found the same general pattern as in the adults.

It was true that the canines were reduced in the female sex in some families, notably the apes. This was, however, a difference of degree only, and did not materially affect the picture.

He looked forward to seeing Professor Hallett's demonstration. He had found the wear facets very well marked in models of Australian aborigines, shown him by Professor Campbell of Adelaide.

Replying to Mr. Chapman, he thought the main objection to the classical theories concerning the articular eminence was that the overbite was a development of the last 1000 years, while the eminentia had been present for at least a million years.

oOo

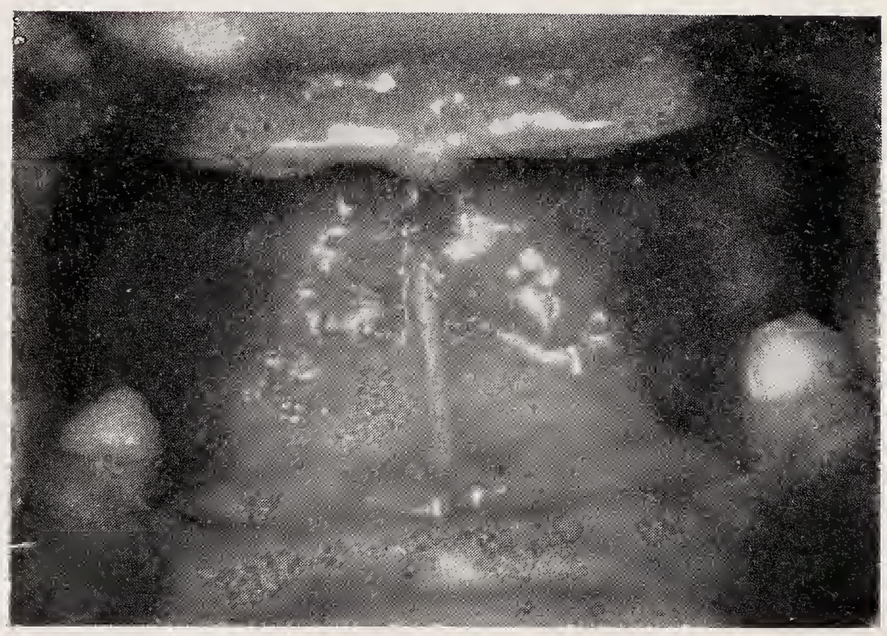
RESTORATIVE TREATMENT OF ANODONTIA IN A DEVELOPING CHILD

By **H. L. LEECH**, B.D.S., F.D.S., Dip. Orth.

CASE REPORT

THE patient, a boy aged 10 years 3 months, first attended in 1949 when he was $4\frac{1}{2}$ years old because it was noticed that none of his teeth had erupted except two lower deciduous molars a year previously (*Fig.* 1).

A



B

Fig 1.—A, Model age: 10 years 3 months. B, Intra-oral view.

Radiographic examination showed that these were indeed the only teeth present, there being no evidence of the development of the remaining deciduous dentition or any of the permanent teeth (*Fig.* 2).

FAMILY HISTORY.—There was an absence of $\overline{21|12}$ in the mother, but there was no history of abnormalities in the father, sister, or grandparents as far as is known.

ON EXAMINATION.—Other signs of ectodermal dysplasia were sought. His hair was fair, of fine texture, and not unduly sparse in quantity. The nails and sweat-glands were normal.

Muscle Resting Pattern.—With the mandible in its physiological rest position the lips were competent.

Muscle Behaviour Patterns.—The swallow was of an infantile type, with a thrust of the tongue between the upper and lower gum pads against the lower lip which contracted a little. There was a tendency for the tongue thrusting to be maintained after dentures were fitted.

Fig. 2.—Lateral radiograph in rest position.

Skeletal Pattern (*Fig.* 3).—The jaws were well developed, with a mandibular angle of average size (F–M angle 27°). In the physiological rest position the skeletal classification was Class I, angles S.N.A. and S.N.B. being identical at 78°.

TREATMENT.—Full upper and partial lower dentures were made in such a way that, with the mandible in its rest position, there was a freeway space of normal proportions—about 2 mm. This rest position and freeway space were checked from lateral skull radiographs with the dentures in place.

The retention of these dentures was much better than anticipated. He became accustomed to them in a very short time and managed a meal quite comfortably just after their insertion.

Given at the Sheffield meeting held on May 6, 1955.

Renewals were necessary just fifteen months later. It was noticed that the skeletal growth had increased the vertical height, resulting in an excessive freeway space and overclosure of the mandible on occlusion

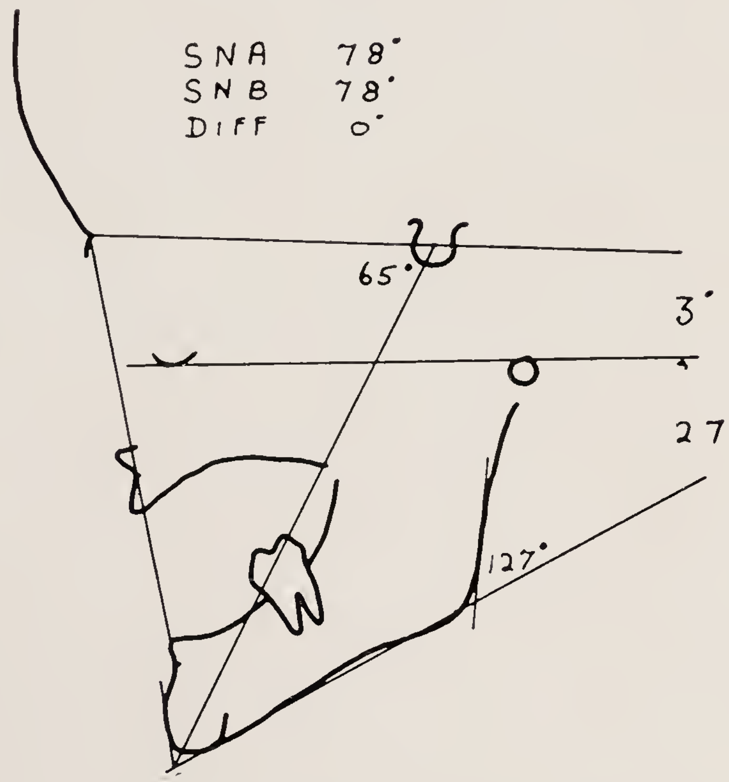


Fig. 3.—Tracing of lateral radiograph.

	SNA	SNB	DIFF
13-2-50	78°	78°	0°
8-2-52	79°	81°	-2°
5-1-54	80°	84°	-4°

Comment.—Lateral skull radiographs have been taken at each visit with the mandible in its physiological rest position and the growth studied from tracings (*Fig.* 4).

The anterior part of the cranial base S–N has increased in length only 3·5 mm., which supports its use as a relatively stable plane of reference for studying facial growth. The composite tracings show that facial growth has taken place in a downward and forward direction relative to the cranial base.

The physiological rest position of the mandible has remained remarkably constant during growth, as seen from the SN–MP angles. The gonial angle has remained fairly constant.

The increased vertical height and corresponding increase in the freeway space is shown in the differences between the linear measurements N–A and N–B (*Table* 1).

Allowing for a margin of error in obtaining the mandibular rest position, it seems from the SNA–SNB angles that the increasing prognathism has been greater in the mandible than the maxilla, i.e., an increasing Class III tendency. (*Fig.* 4.)

One final conclusion is that the growth of the jaws has been affected little, if at all, by the absence of the masticatory forces normally transmitted to the basal bones via the teeth and alveolar bone.

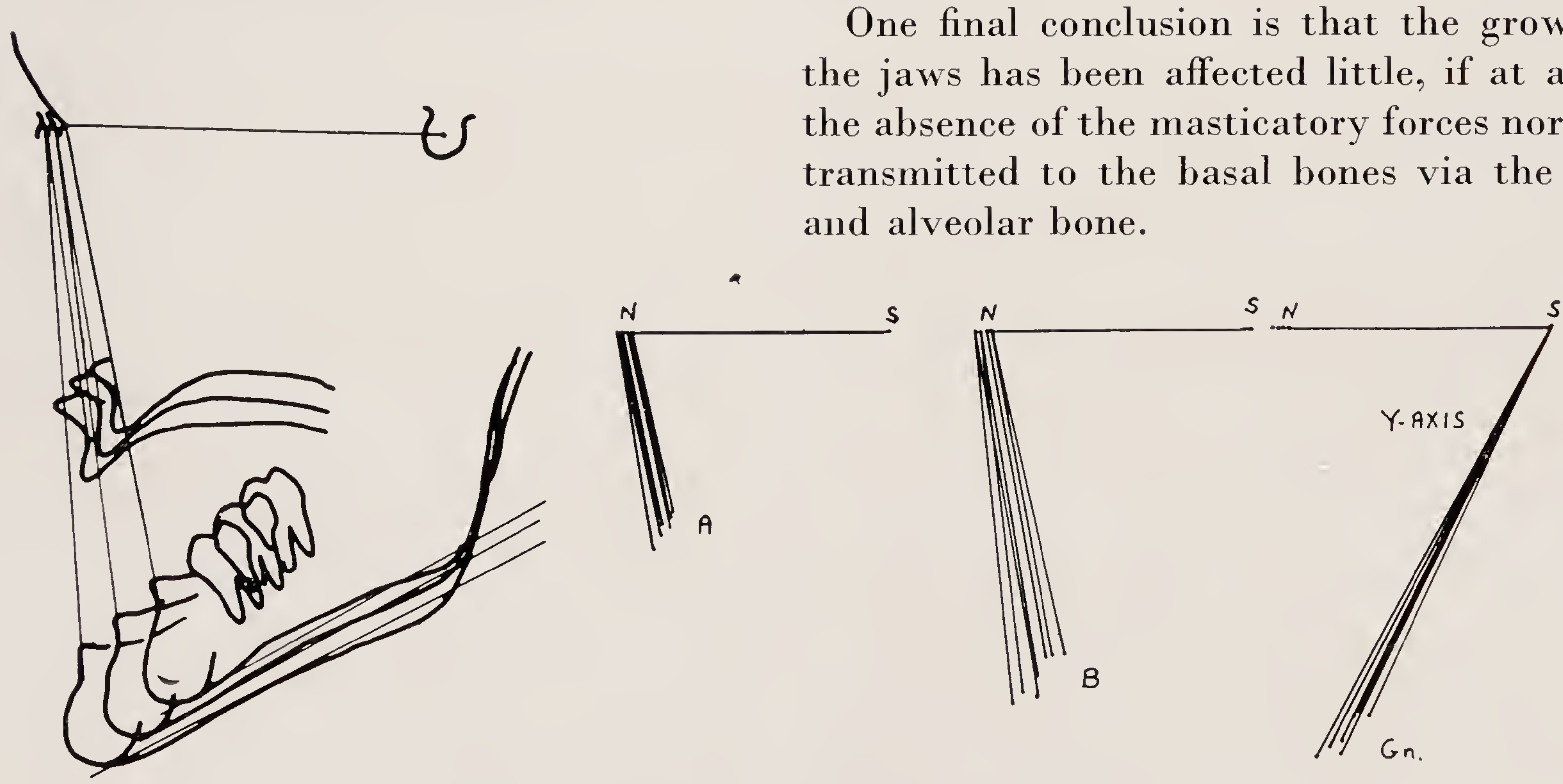


Fig. 4.—Superimposed tracings on S.N. plane.

giving a slight Class III relationship. Growth in the maxilla was mostly apparent in the tuberosity region, where the heels of the upper denture now dug into the gum short of the arch length.

New dentures were made to fill in the extra interalveolar space.

Further remakes or relinings have been necessary at intervals ranging from six months to one year.

I would like to thank Mr. Hovell, Director of the Orthodontic Department of the Royal Dental Hospital of London, and Mr. Ballard, Director of the Orthodontic Department of the Eastman Dental Hospital, London, for permission to publish this case.

Table I

DATE	AGE	GONIAL ANGLE	SN/MP	SNA	SNB	SNA/SNB DIFF.	NA	NB	AB	NA/NB	SN	Y	Y/SN ANGLE
13.2.50	5	127°	30°	78°	78°	—	mm. 44	mm. 78	mm. 34	56·4	mm. 61	mm. 105	65°
2.10.50	$5\frac{8}{12}$	125°	29°	79°	81°	−2°	45	78	33	57·7	61	106	63°
10.4.51	$6\frac{2}{12}$	125°	30°	78°	80°	−2°	46	80	34	57·5	62	108	62°
8.2.52	7	125°	31°	79°	81°	−2°	47	83	36	56·6	63	113	63°
5.8.52	$7\frac{6}{12}$	127°	29°	80°	83°	−3°	49	87	38	56·3	63	117	62°
22.4.53	$8\frac{2}{12}$	126°	31°	78°	80°	−2°	50	88	38	56·8	64·5	117	64°
5.1.54	$8\frac{11}{12}$	127°	28°	80°	84°	−4°	52	90	38	57·7	64·5	120	61°

DISCUSSION

The President, Mr. Pringle, thanked Mr. Leech for his paper and said that there was some doubt in his mind concerning the eonstancy of the rest position. In a previous paper Mr. Leech had not made any qualifications in discussing the rest position, which Mr. Pringle thought varied with the positions of the head. He asked Mr. Leech to give his definition of the physiological rest position of the mandible and describe how he determined it. He thought there was some doubt about the accuracy in determining the rest position in this case of anodontia as the boy was shown to have a different appearance when viewed in the film and from the lateral radiographs.

Mr. Tulley commented on thc possibilities of studying the growth of the basal elements of the jaws in such cases of anodontia. He asked Mr. Leech whether the patient swallowed with the teeth in occlusion when the dentures were fitted and how he took the bite.

Mr. Chapman commented on the fact that he thought the boy had the appearance of Angle's Class II, division 1 and Mr. Leech had said that the jaw relationship had a tendency to Class III. Another explanation of the more forward position of the mandible, which the cephalometric traeings reveal, eould be that the case is one of those in which a normal forward movement of the mandible has occurred; the photographs of the boy suggest that this is more probably the correct one as there is no suggestion of a Class III appearance but rather a Class II or post-normal relation of the mandible which in the course of development has changed to a normal relation.

Mr. Leech, in replying to the discussion, said in answer to Mr. Pringle that his definition of the physiological rest position was that position of rest of the mandible where the elevators and depressors are in a condition of reciprocal tonus and from which all movements of the mandible start. The method of obtaining the physiological rest position was to get the patient to swallow and say 'M' and then wait for his jaw to go into the rest position.

With regard to the taking of the bite, this was taken by clinical assessment and checked with the lateral radiographs, closing 2–3 mm. from the rest position. With regard to swallowing, he could not give a definite answer, but he had noticed that sometimes the teeth were oecluded and other times the tongue thrust, which was present without the dentures, was maintained after their insertion. Mr. Leech said in reply to Mr. Chapman that it was very difficult to assess the growth and the relationship of the edentulous jaws as all movements had to be made from an arbitrary rest position.

oOo

THE RELATIONSHIP OF THE LIP LINE TO THE INCISOR TEETH*

By **W. A. NICOL**, L.D.S., D.D.O.

WHILE it is known that the muscles surrounding the teeth influence the position that the teeth will adopt, their study has been confined almost entirely to their function (Ballard, 1948, 1953; Gwynne Evans, 1948; Rix, 1946, 1953; and others). It is obvious that in function the muscles exert a more powerful and more dynamic influence. Hovell (1955) suggests that the lips and cheeks at rest fulfil a passive role and that the size and shape of the tongue determines the shape of the dental arches.

When the teeth erupt, they erupt into a space between the tongue on the inside and the lips and cheeks on the outside. The shape of this space is variable from individual to individual, as are all human features. But the extent and the manner of its variation has not been investigated. The shape of the inner surfaces of the lips and cheeks, even if only fulfilling a passive role, must have some effect on the position which the teeth will adopt.

The inner surfaces of the lips form the anterior boundary of this space into which the teeth erupt, and offer a suitable starting point for study. In a preliminary survey (Nicol, 1954) the relationship of the lips to the incisors in cases of deep overbite was observed clinically. The lower lip was observed to cover part and, in some cases, all of the labial surfaces of the upper incisor teeth. Pringle (1955) has since made some valuable observations on the combined effects of the lip seal, the height which the lower lip reaches on the upper incisors, and the type of swallow, in cases of treated Angle's Class II, division 1 malocclusion.

In the present paper it is proposed to investigate the relationship of the lip line to the upper incisor teeth in a representative group of schoolchildren, to establish the relationship existing in normal occlusion, and to investigate the relationship in cases of malocclusion.

METHOD AND MATERIAL

A random sample of 44 schoolchildren attending Bristol Dental Hospital for routine dental treatment provided the material for the principal part of the investigation. Their ages ranged from 9 years to 14 years. Of the 44, 30 had normal occlusion, 8 had an Angle's Class I malocclusion, 3 Angle's Class II, division 1, and 3 Angle's Class II, division 2.

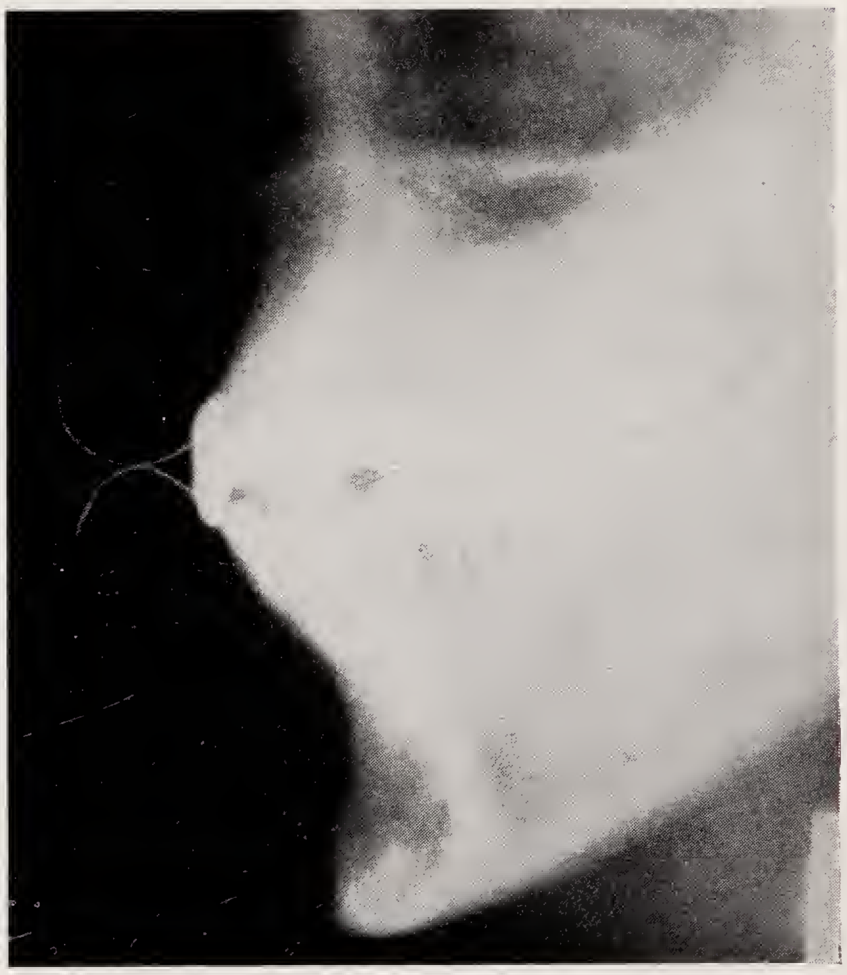


Fig. 1.—An example of a profile X-ray with barium paste, showing up the surfaces of the lips in the midline.

A profile X-ray was taken of each child; barium paste was smeared on the lips in the midline to show clearly the inner surfaces of the upper and lower lips. A cephalometer was not available for this work. The X-rays were taken with an ordinary dental X-ray machine at a target film distance of 3 ft. The central ray was centred on the lips (*Fig.* 1).

* Given at the Sheffield meeting held on May 6, 1955.

The parts being examined and measured, the lips in the mid-sagittal plane, and the upper incisor teeth are so near to one another —indeed, touching one another—that the effects of non-parallelism will have an effect on accuracy or distortion which is scarcely significant. However, the effects of enlargement of the image due to the divergent X-rays will have to be taken into account if measurements are to be made directly on the X-ray film. This increase is measurable (Logan, 1938) and in the present instance, with a target film distance of 3 ft. and an object film distance of about 3 in., is approximately 10 per cent—a convenient figure where calculation in decimals is concerned.

It was realized that there was scope for considerable error during the procedures of taking the X-rays and measuring the resulting tracings. The lower jaw and the lips, being exceedingly mobile structures and subject to the will and emotions of the patient, might present differences in relationship even under the scrutiny of the operator taking the X-rays. Five cases were therefore X-rayed twice, i.e. by two entirely separate operations. The resulting ten tracings were measured in a random order and the measuring errors calculated.

The method of measuring the tracings was as follows: The occlusal plane as used by Downs was drawn in (Downs, 1948). (The plane is represented by a straight line bisecting the first molar cusp height and the incisal overbite.) This line was projected forward beyond the incisors and lines parallel to it were drawn, the lower just touching the incisal edge of the upper incisor and the upper line the highest point on the curve of the lower lip. The distance between these last two parallel lines was measured in millimetres and represents the level of the lip line above the incisal edge of the upper central incisor teeth (A in *Fig.* 2).

RESULTS

Of the 30 cases of normal occlusion, 27 values were used in the statistical analysis. The remaining 3 cases fell well outside the range and were omitted from calculations. The measurements were made to the nearest tenth of a millimetre.

In 27 cases of normal occlusion the range was shown to be 2·8 mm. to 7·0 mm., with a mean of 4·8 mm. and a standard deviation of 1·2. The correction for measuring errors

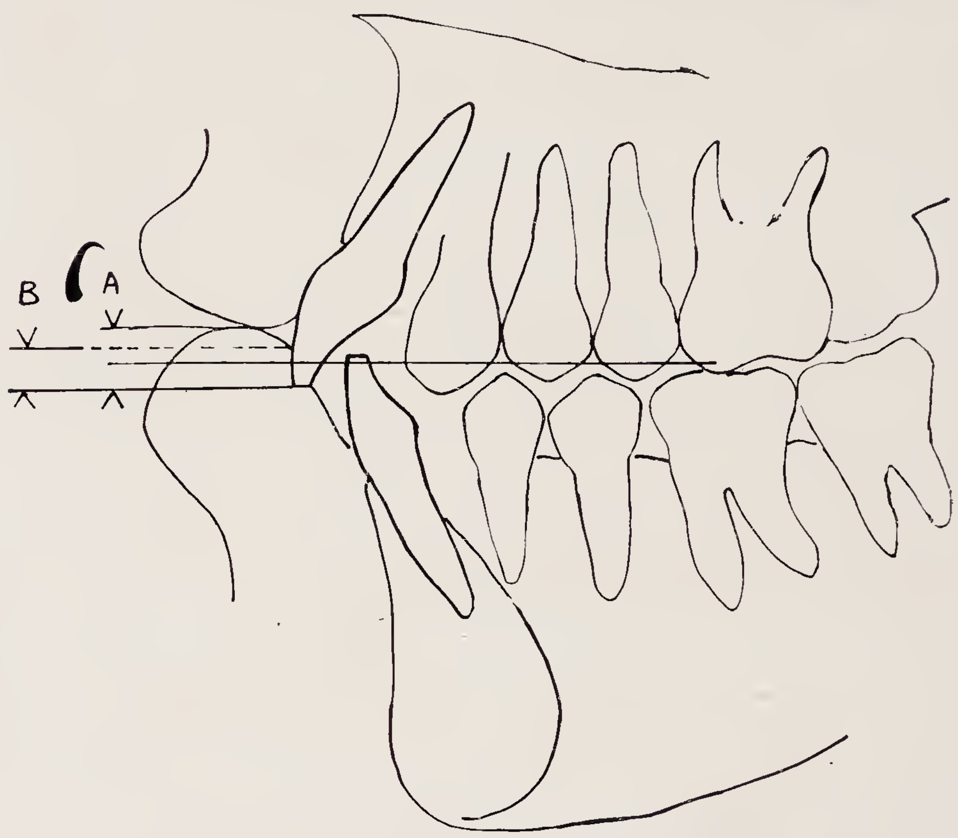


Fig. 2.—Tracings of X-ray showing: A, Total height of lip above incisal tip of upper central incisors; B, Height of lip in contact with central incisors.

amounted to half the observed variations (*Fig.* 3).

In the group of 8 Angle's Class I malocclusion, if one value which is well outside the range is left out, a range of 2·5 mm. to 5·9 mm., with a mean of 4·6 mm. was obtained. This shows no appreciable variation from the normal.

The three values for Angle's Class II, division 2, were measured as 5·8 mm., 6·0 mm., and 7·1 mm.—all are above the mean value for normal (*Fig.* 4). Conclusions cannot be drawn from so few cases.

In the Angle's Class II, division 1, cases, the measurements could not be made as in every case the lower lip was below the level of the tip of the upper incisors.

With the kind permission of Mr. C. F. Ballard, I was able to make tracings of a number of cephalometric X-rays at the Eastman Dental Hospital, London. Some of these X-rays were of the patients who had had no orthodontic treatment as yet, and some were

of patients who were either under treatment or had had their treatment completed. A strikingly similar range of values was obtained.

In the untreated cases, Angle's Class I malocclusions showed a range of 2·5 mm. to

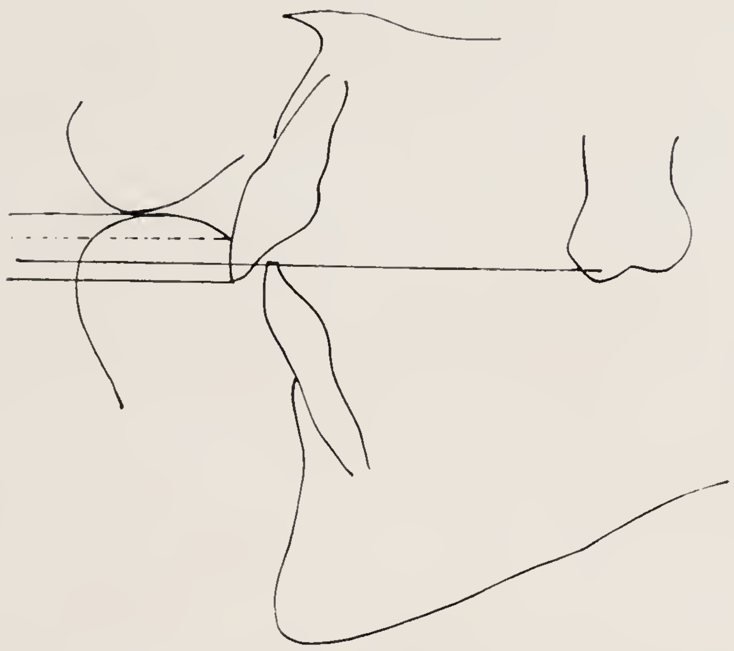


Fig. 3.—Example of a tracing in a normal occlusion.

7·0 mm., with a mean of 4·8 mm. in a group of 21 cases. Two were omitted from the calculation, where there was no coverage by

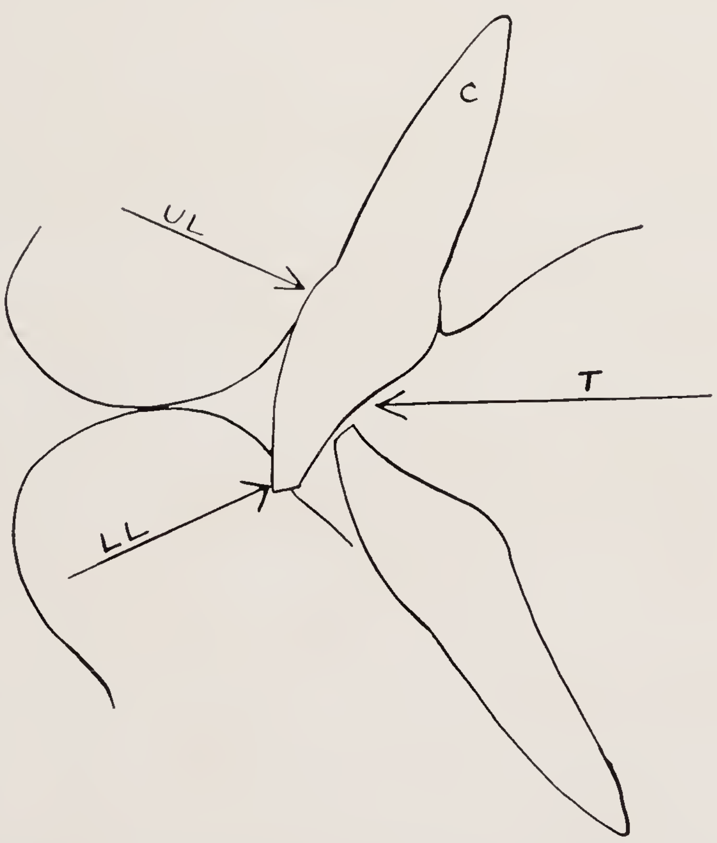


Fig. 5.—Diagram illustrating the points of application of the muscle forces controlling the incisor teeth.

the lower lip. Two cases of Angle's Class II, division 2, showed readings of 6·3 mm. and 6·9 mm., once again being above the normal mean value. In 18 treated cases the range was 2·8 mm. to 7·0 mm., with a mean of 5·0 mm.

Values have been given to the nearest tenth of a millimetre for comparison of the various groups. However, in view of the value for

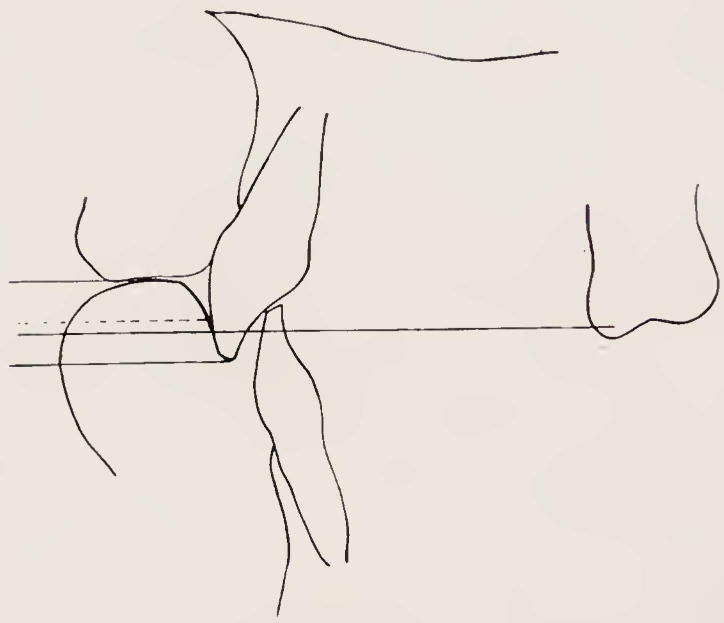


Fig. 4.—Example of a tracing in a case of Angle's Class II, division 2.

measuring errors, a more realistic statement of the group of normal occlusions would read: range 3 mm.–7 mm., mean 5 mm., standard deviation 1.

This survey shows that in a normal occlusion, or in a malocclusion of a local nature, the lower lip will be found to rise above the level of the incisal margins of the central incisors to a height of 3 mm.–7 mm. The height of lower lip in actual contact with the labial surfaces of the central incisors is less than this (B in *Fig.* 2). The actual amount of lower lip in contact with the upper incisors will depend on the shape of the inner surface, both in convexity and in the shape of the junction of the upper and lower lip—the lip line. The measurement of the actual contact with the central incisors (*C* in *Fig.* 2) showed a value of about 2 mm. less than the height of lip above the incisal edge. The inner surface of the upper lip as it curves away from the junction with the lower lip may not contact the upper central incisors at all. In cases near the upper limit of values in the foregoing survey the clinical crown would have to be greater than 9 mm. in height for the upper lip to contact the enamel of their labial surfaces.

DISCUSSION

In assessing the possible effects of the inner surfaces of the lips as a controlling force in the position which the incisors will adopt, the slopes of their surfaces in relation to the teeth and the area of application must be taken into

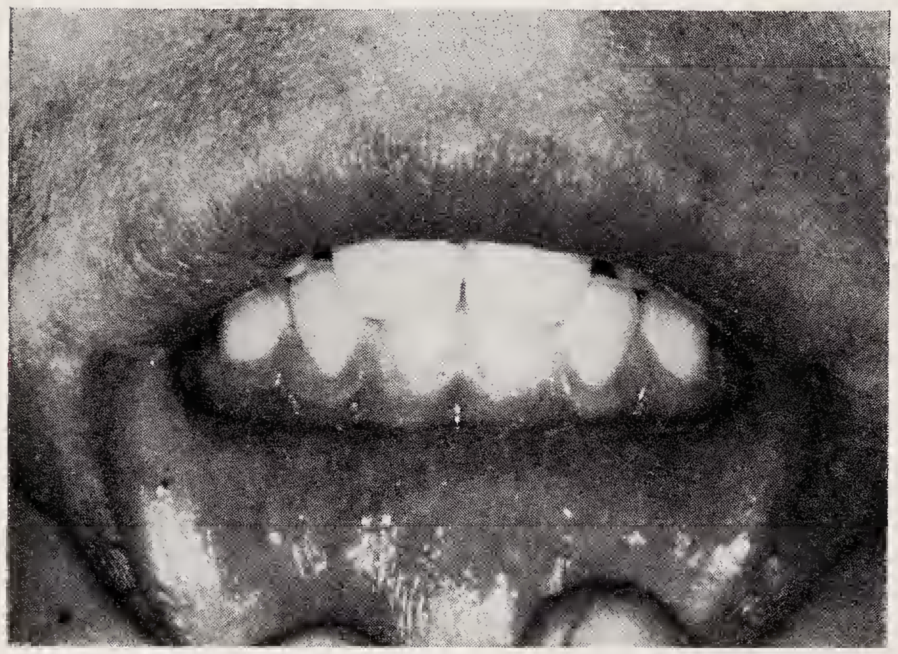


Fig. 6.—Lower lip held aside in a case of Angle's Class II, division 2. The lateral incisors are entirely covered by the upper lip.

Fig. 7.—The lips in Angle's Class II, division 2 malocclusion.

Fig. 8.—The lips in Angle's Class II, division 2 malocclusion.

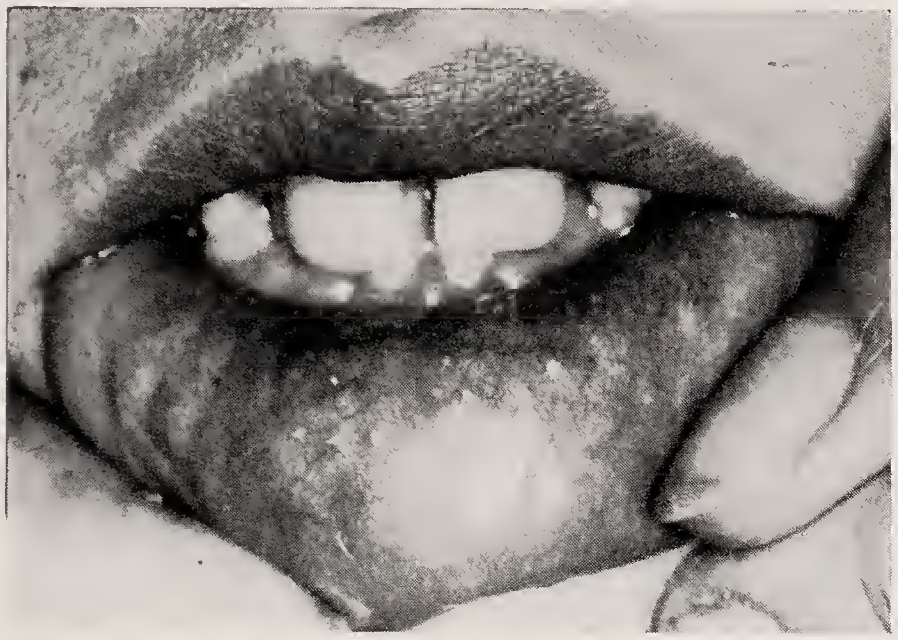
account. The inner surface of the upper lip where it contacts the dento-alveolar process is roughly parallel to it; also, being nearer the fulcrum of tipping movement of the incisor, its effort is further reduced. On the other hand, the lower lip's inner surface lies at a tangent to the labial surface of the incisor, preventing its further eruption and preventing labial tilting of the incisor at its most mechanically advantageous point. It will be seen, therefore, that the lower lip is the major controlling force in preventing the upper central incisors from being tilted labially by the thrust of the tongue (*Fig.* 5).

From profile X-rays with radio-opaque paste on the midline of the lips, the relation of the lip to the central incisors only can be assessed. The relation of the lateral incisors to the lips will depend on the shape of the lip line, whether it is straight, curved upwards, or curved downwards. Also, it will depend on the height to which the lateral incisors have erupted or grown in relation to the lip line.

The few Angle's Class II, division 2, cases measured in this series would suggest (though not prove) that there is a greater lower lip coverage of the central incisors than in normal occlusion. This is borne out clinically. If the lower lip in a Class II, division 2, case is pulled away, a large area of labial surface of the central incisors is seen. On the other hand, the labially inclined lateral incisors are not seen—they are completely covered by the upper lip (*Fig.* 6). Is it unreasonable to postulate that in Class II, division 2 malocclusion the central incisors are tilted lingually by the control exerted by too great a depth of lower lip, while the lateral incisors receive only the weaker controlling force of the upper lip?

It was with this in mind that an attempt was made to correlate the angle at which the upper and lower incisors meet with the height of lip line above the incisal margins of the

upper incisors. This was done in the group of normal occlusions. The figures were plotted against one another on a graph, but no significant correlation was noted. However, with a larger group of Angle's Class II, division 2



A B

Fig. 9.—A, The lower lip held aside to show a large area of the labial surface of the central incisors in a case of deep overbite. B, The lips of this case in repose are not typical of Angle's Class II, division 2 malocclusion.

Fig. 10.—Anteroposterior X-ray with barium paste along the lip line.

or deep overbite cases, a similar correlation might lead to more positive results.

A lip pattern of distinctive morphology must surely exist in Angle's Class II, division 2 malocclusion. In Mr. Pringle's Presidential address this year he spoke of a case of his "giving the outward appearance of a mild skeletal II with Class II division 2 type of mouth". Most orthodontists could, I feel sure, diagnose an Angle's Class II, division 2 malocclusion before the patient opens his mouth. *Figs.* 7 and 8 show this typical lip morphology.

Fig. 9 illustrates a case of deep overbite; the lateral incisors have not yet erupted, but it appears that they will probably come under the influence of the lower lip and will not therefore adopt the position typical to Angle's Class II, division 2.

If much of this discussion has been concerned with Angle's Class II, division 2 malocclusion, it is because this anomaly presents a pattern of the upper incisors which will repay study. The bony and muscular elements present a typical pattern of which much remains to be learned.

Fig. 10 shows an anteroposterior X-ray with barium paste along the length of the lip line. An investigation of normal and Angle's Class II, division 2 malocclusion using this method might bring the reward of further knowledge in this field.

SUMMARY

A study of the relationship of the lip line to the upper incisors was undertaken.

A group of 44 schoolchildren attending Bristol Dental Hospital for routine dental treatment, and tracings of 39 X-rays from the Eastman Dental Hospital, London, provided the material for the investigation.

From tracings of profile X-rays, the height of lower lip above the incisal margin of the upper central incisors was measured.

SUMMARY OF STATISTICAL FINDINGS

Source of Material	Occlusion	Numbers	Lower Lip Height above Incisal Margin of Upper Central Incisors		
			Range	Mean	Actual Readings
Sample of 44 Bristol school-children	Normal	27	mm. 2·8–7·0	mm. 4·8	mm.
	Class I	7	2·5–5·9	4·6	
	Class II div. 2	3			5·8, 6·0, 7·1
Cephalometric X-rays from Eastman Dental Hospital, London	Class I	19	2·5–7·0	4·8	
	Class II div. 2	2			6·3, 6·9
	Treated cases	18	2·8–7·0	5·0	

In normal occlusion, Angle's Class I malocclusion, and in treated cases a very similar measurement was obtained, which can be expressed as 3–7 mm. range, with a mean of 5 mm., and a standard deviation of 1.

In the 5 cases of Angle's Class II, division 2 from both sources the values were in all cases above the mean for normal occlusion.

The possible effects of lower and upper lip control on the incisors is discussed.

Acknowledgments.—I am indebted to Mr. C. F. Ballard for allowing me to use cephalometric X-rays from his Department; to Dr. Maurice V. Stack for calculating the statistical data, and to the Bristol Medical Photography Department for the photographs.

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DISCUSSION

The President, Mr. Pringle, thanking Mr. Nicol for his paper said he thought it would be interesting if Mr. Nicol investigated the relationship of the lip positions to the deciduous dentition, with particular reference to Class II, division 2. This would make a serial study. He believed that it was more important to consider the lips in function rather than their actual resting position when they were sealed. He thought that it was also important to take all the structures into account and not just the lips. The position of the tongue had considerable significance in swallowing. He asked Mr. Hovell to open the discussion.

Mr. Hovell thanked Mr. Nicol for his paper, to which he had listened with great interest. He said that it demonstrated a definite relationship between lower lip coverage and the axial inclination of the upper incisors, and he asked whether any significant correlation had been found between the degrees of coverage and of retroclination, and from this point of view thought it would have been better to relate the coverage to the upper incisors–Frankfort-plane angle rather than the angle between the long axes of the upper and lower incisors or to the different divisions of Angle's classification.

Mr. Hovell was not sure that he agreed with Mr. Nicol's conclusion that the retroclination of the incisors was due to a high position of the stomion, but felt that the reverse was the case. When the axial relationship and central occlusal position of upper to lower incisors were disturbed by retroclination of the former, this always resulted in overeruption in both upper and lower labial segments, e.g., Class II, division 2. This overeruption of the uppers must result in a greater coverage of them by the lower lip. He thought it would be better therefore to relate the position of the stomion to the occlusal plane, and if this relationship showed a significant correlation with the degree of the incisor retroclination he would be more inclined to accept it as a possible aetiological factor.

Lastly, Mr. Hovell would have liked to have heard something about those variations outside the normal statistical range, and therefore excluded, as these extreme

cases often gave valuable pointers as to aetiology. He felt that this work on a little understood type of malocclusion should be continued and extended and should produce useful information.

Mr. Kettle said that in studying cases with hare-lip there was a relationship between the position of the incisors, the thickness of the lips, and the functional activities in this region. Mr. Nicol had not mentioned this and he wondered whether he had any observations to make.

Miss Clinch said she thought it was a very interesting observation that the lower lip came up so far on the labial surfaces of the upper incisors in certain types of malocclusion. Is it always the tongue thrust that causes the upper incisors to tilt labially if the lips are not in contact at rest? She thought it was a pity that Mr. Nicol had omitted all Class II, division 1, cases from his study as it was possible to have this malocclusion and have a lip seal at rest. Mr. Nicol had shown one case which he said would not develop into the Class II, division 2, type; Miss Clinch thought that this was not a reasonable assumption.

Mr. Walpole-Day asked Mr. Nicol if he could give details of the way he prepared his barium paste and how he applied it.

Mr. Tulley said he thought that the emphasis must be placed on the function of the lips rather than their position, but that the tension of the lips in their resting position was important. He asked the question: How often are the lips at rest, and emphasized the point made by Mr. Rix in 1952 that attention must be focused on the activities of the lower lip, as the upper lip was almost physiologically redundant in relation to the position of the incisors.

Mr. Nicol, replying to the discussion, said he would like to thank those people who had offered advice for further research, particularly Mr. Pringle's remarks on the relation of the lips to the deciduous incisors as a serial study and Mr. Hovell's suggestion of reference to the incisor–Frankfort-plane angle. Mr. Nicol said in reply to several speakers that he believed function was the most important factor. He thought that the rest position of the lips indicated the resting potential for their function. He emphasized this by saying that the dynamic forces were obviously those which had the main effect, but he thought that his investigation would contribute to the overall study of aetiology. He thanked Mr. Kettle for his suggestion concerning the study of the thickness of the lips. He himself had not investigated cleft-palate cases in this respect. Replying to Miss Clinch, he said in the Class II, division 1, case that he had traced there was no actual lip coverage so that he was unable to make any measurements. He felt that he was not in a position to make a statement on the type of case where the lips actually were in contact.

With reference to the case where he had suggested that a Class II, division 2, incisor relationship would not occur with the eruption of the lateral incisors, he based this on the fact that where the line of the lips is straight, viewed from the front, it is unlikely that the upper lateral incisors will be proclined to give the typical Class II, division 2, picture; they will come under the same muscular environment as the central incisors. In reply to Mr. Walpole-Day he said that he used barium powder mixed up with very little water to form a thick paste which he injected between the lips with a hypodermic syringe to give even coverage, using it rather like a cake-icing machine. Replying to Mr. Tulley he said that he had already emphasized his views on the fact that function was the most important feature and that the lips were not at rest for any great length of time. Some people used their lips more than others.

THE CLINICAL ASSESSMENT OF THE UNERUPTED MAXILLARY CANINE

By **D. T. HARTLEY,** L.D.S., D.Orth. R.C.S.
Turner Dental School, Manchester

THE maxillary permanent canine normally erupts between the ages of eleven and twelve years. For a year or two before its eruption the thin bony covering of its crypt forms a slight bulge on the labial surface of the alveolar process above the deciduous canine, and can be detected, high up towards the sulcus, by digital palpation.

Fig. 1.—Normal unerupted canine ($11\frac{1}{2}$ years).

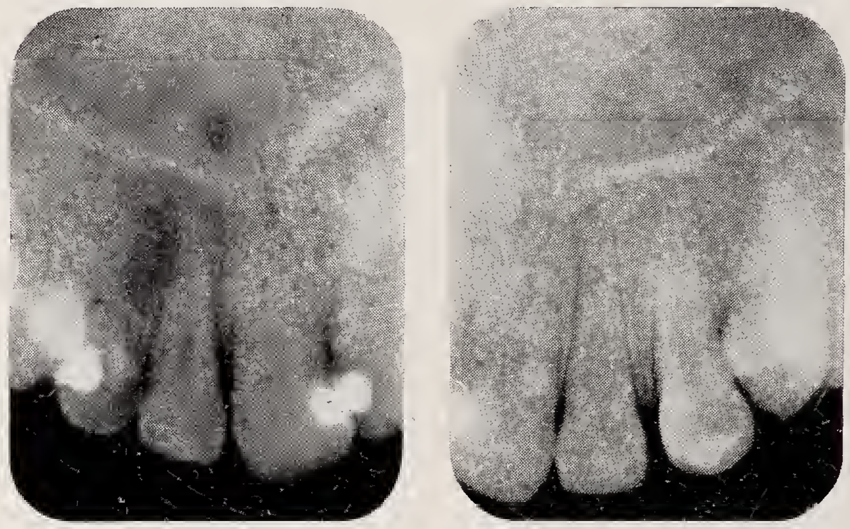

Fig. 2.—Congenital absence of $\underline{3|}$, normal eruption of $\underline{|3}$ ($12\frac{3}{4}$ years).

At this stage, routine radiographic examination produces a periapical film such as *Fig.* 1. Resorption of the root of the deciduous canine is occurring ahead of the permanent crown. The root of the permanent tooth shows a considerable degree of development, which is normally complete by thirteen to fourteen years of age, i.e., within one to two years of its eruption, the fairly complete development of the root by the time of eruption being a notable feature of the permanent canine. The long axis of the tooth has a moderate amount of mesial inclination of the crown, but the general line conforms to that of the adjacent lateral and first premolar teeth.

Diagnosis.—At variance with this picture of the normal unerupted canine are the circumstances when the unerupted tooth is displaced. This condition may be disclosed: (*a*) During routine radiographic examination of the mixed dentition; (*b*) When retention of a deciduous canine beyond the age of thirteen years is investigated; (*c*) During investigation of the absence of the canine from the permanent dental arch of an adolescent or adult patient, with no definite history of its extraction.

It may be noted here that it is extremely rare for the canine to be congenitally absent. *Fig.* 2 illustrates this infrequent condition; $\underline{3|}$ is absent, $\underline{C|}$ is retained but its root shows considerable resorption, while $\underline{|3}$ has erupted normally.

Frequency.—Although the upper canine is second only to the third molars in order of frequency of non-eruption and malposition, this condition is not encountered very often. Rohrer (1929) found it in 2 per cent of approximately 3000 patients radiographed. This frequency was quite well confirmed by Mead (1930) with a figure of 1·6 per cent in 1462 patients.

Type of Displacement.—Because of its developmental position within the maxilla and relative to the other teeth, demonstrated by Logan and Kronfeld (1933), malpositions of the canine most frequently consist of an inclination of its crown mesially and lingually. Rohrer noted this in roughly two-thirds of his cases.

Given at the Sheffield meeting held on May 6, 1955.

Since this particular type of displacement of the canine presents a well-defined clinical problem, this paper is limited to its study and is thus concerned with the maxillary permanent canine which is delayed in eruption and displaced into a lingual malposition.

Fig. 3.—Abnormal unerupted $\underline{3|}$: topographic occlusal film taken with X-ray tube in median plane (20 years; patient A).

Clinical Examination.—When displacement of the unerupted canine is suspected, palpation of the labial and lingual surfaces of the alveolar process often provides preliminary information.

Where the deciduous canine is present and the normal bulge of the outer alveolar plate over the crown of the permanent tooth cannot be detected, it is likely that the permanent crown is displaced lingually to some extent. The persistence of the more linear swelling produced by the bone covering the relatively unresorbed root of the deciduous tooth is additional evidence of abnormality.

Palpation lingually may disclose a bony swelling if the crown of the permanent canine is displaced in this direction and lies near the surface. The firmness and irregularity of the fibrous connective tissue of the palatine rugæ can make this examination deceptive.

Radiographic Examination.—Radiographic investigation is the next step. One exposure, usually of a periapical film, is made first, and from an examination of this the other views necessary are determined.

The radiographs must show: (*a*) The position of the crown of the canine relative to the adjacent teeth—vertically, mesiodistally, and labiolingually; (*b*) The position of its apex—vertically, mesiodistally, and labiolingually; (*c*) The direction of its long axis. Additional information, such as the degree of resorption

Fig. 4.—Abnormal unerupted $\underline{3|}$: periapical film (patient A).

of the root of the deciduous canine when present, will obviously be available from these films.

To fulfil these requirements radiographs taken from at least two different directions, approximately at right angles, are essential. The use of a single radiograph, giving a view from only one direction, frequently leads to failure to appreciate the true position of an unerupted canine.

A topographic (root length) occlusal film of the upper incisor region is often used, but alone it is relatively valueless. It is not uncommon to find the diagnosis of "horizontally unerupted canine" made from a single radiograph of this type such as *Fig.* 3, taken with the X-ray tube in the median plane. This diagnosis is quite unjustifiable—the true inclination of the long axis of the unerupted tooth cannot be judged; in addition, the mesiodistal position of the canine apex and the vertical relation of the crown to the incisor apices are distorted.

One, or sometimes two, periapical radiographs are usually sufficient to show accurately the mesiodistal and vertical positions of

crown and apex, and the inclination of the long axis in the vertical plane. *Fig.* 4 is a periapical film of the same patient from which the relation of the canine apex to the apex of the first premolar, and the vertical and mesiodistal relation of its crown to the root of the

Fig. 5.—Abnormal unerupted $\underline{3|}$: topographic occlusal film taken with X-ray tube in canine fossa (patient A).

lateral, can be judged. The resorption of the deciduous canine root can also be seen.

The more horizontal the canine is lying, the greater is the need for separate radiographs to cover its entire length with accuracy. In fact, Field and Ackerman (1935) writing on this particular problem considered it necessary to have three periapical views to obtain the fullest information.

A topographic occlusal film taken from the direction of the canine fossa provides a somewhat similar view over a wider field, but may be inaccurate in the vertical plane. *Fig.* 5 shows this view, and should be compared with the periapical radiograph of the same case (*Fig.* 4) and with the midline topographic occlusal film (*Fig.* 3).

The labiolingual relation of the unerupted canine is best determined by a cross-section occlusal film giving a plan view of the upper incisors. Only by this means can the closeness of the canine crown to the incisor roots, the buccolingual position of the apex, and the direction of the long axis, be accurately determined in the horizontal plane. Hitchin (1951) made some useful comments on the need in these cases for angulating the X-ray tube to obtain an end-on view of the incisors, rather than a general plan of the whole upper arch. *Fig.* 6, showing the cross-section view of the same case, also illustrates the difficulty which may be encountered in obtaining good definition of the teeth in an adult patient (this patient was aged 20 years) because of the

Fig. 6.—Abnormal unerupted $\underline{3|}$: cross-section occlusal film (patient A).

density of the considerable amount of bone through which the X rays have to pass when exposing this type of film. The radiograph shows the crown of the canine to be lying lingually to the lateral and central incisors, with its tip near the midline; the canine apex is in the line of the arch buccolingually.

When the more powerful X-ray equipment necessary for exposing a cross-section occlusal film is not available, and the labiolingual relation of the canine to the other teeth is in doubt, its position is determined with a standard dental X-ray unit by using the tube-shift or Clark localization technique. *Fig.* 7 shows the periapical radiographs produced by the application of this method to the case previously illustrated. The X-ray tube was moved a short distance mesially before the right-hand film was exposed. Noting the relation of the cusp of the canine to the roots of the lateral and central, it appears on

the right-hand film to have moved towards the midline, i.e., it has moved in the same direction as the tube. The crown of the canine therefore lies on the lingual side of the roots of the incisors.

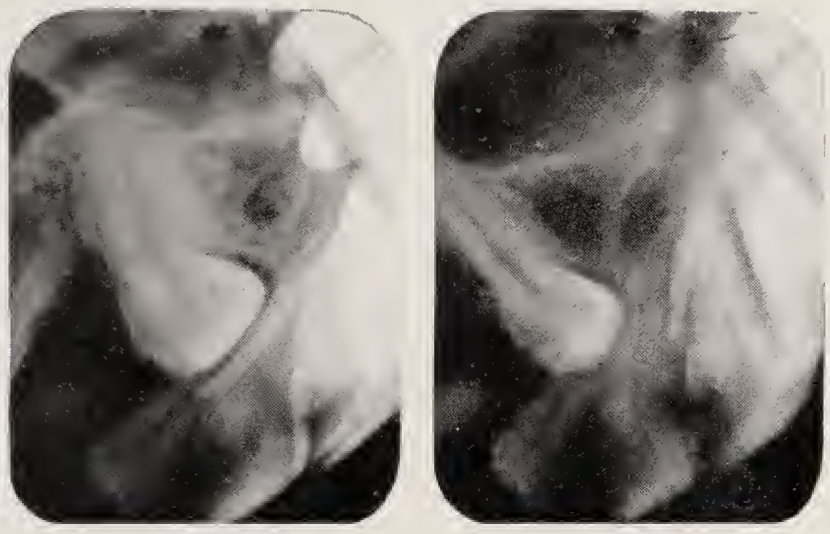

Fig. 7.—Abnormal unerupted $\underline{3|}$: labiolingual localization by tube-shift technique (patient A).

Stereoradiographs are interesting but usually of less clinical value than the preceding methods, and require special apparatus for viewing.

Assessment of Prognosis.—

1. *Position of Permanent Canine.*—The information derived from the radiographs is used to assess the prognosis for obtaining a satisfactory position of the canine within the arch.

The line of the long axis of the canine represents its potential path of eruption. Providing that this is directed towards the surface and not into other teeth, the canine crown will become accessible if full eruption occurs. Once full eruption has taken place a relatively simple orthodontic appliance pressing on the crown will produce tilting of the tooth. The fulcrum for a simple tipping movement is located near the apex, within the apical third of the root. The position of the apex after eruption of the canine thus determines whether or not the crown can be tipped into the arch.

It is therefore necessary that: (*a*) The potential path of eruption shall be directed towards the surface and be unobstructed by other teeth; (*b*) When eruption is complete the apex shall be near the normal position—vertically, mesiodistally, and labiolingually. This implies that the path of eruption must pass through the area occupied by the apex of the normally erupted canine.

The prognosis for the unerupted canine is most favourable when its position conforms exactly with these requirements. In the case shown in *Fig.* 8 the occlusal radiograph shows the crown of the canine to be well clear of the incisors, and not too close to the midline. The apex is in the line of the arch. The periapical view shows that the crown is not very deeply placed. The inclination of the long axis is favourable, being fairly upright, and there is an unobstructed path of eruption. The apex is so placed that eruption of the canine along its present axis will eventually position the apex normally between the lateral and the first premolar. The prognosis is therefore good.

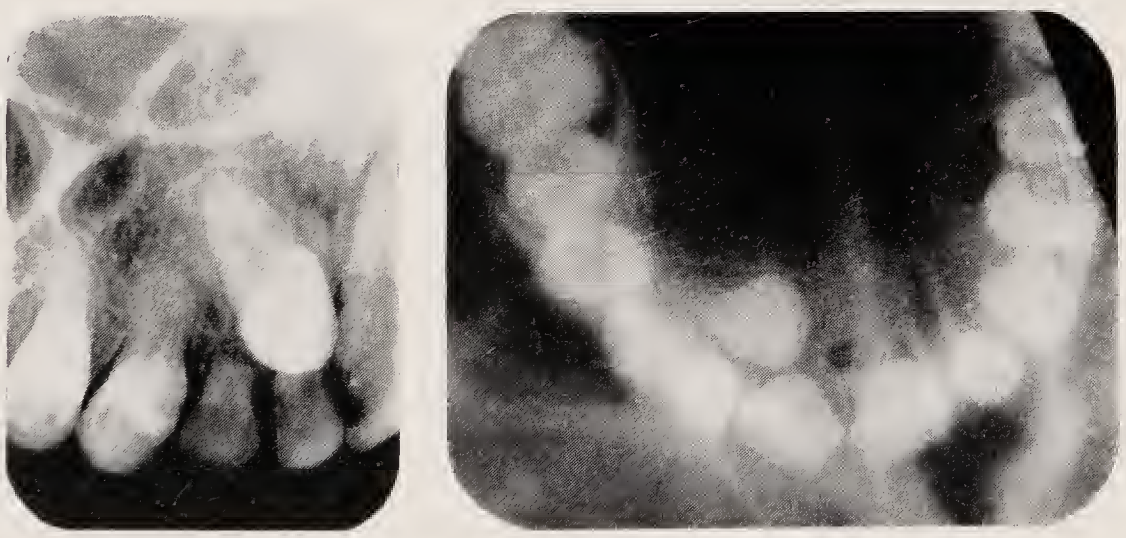

Fig. 8.—Abnormal unerupted $\underline{3|}$: good prognosis ($17\frac{1}{2}$ years).

The initial treatment required is limited solely to the surgical exposure necessary to provide a free path of eruption. The canine can then be left to erupt until its apex is approximately in the normal position, when simple tipping movement by an appliance will ensure its crown being positioned normally in

the arch. This is the type of case which is most likely to prove successful in the hands of the careful practitioner, and its detailed treatment has been adequately covered by Dewel (1945), Lappin (1951), and Fastlicht (1954).

Fig. 9 shows the original position of the unerupted canine in a case of this sort; the patient was aged 15 years. The prognosis is favourable as judged by the criteria suggested. Four months after extraction of the deciduous canine and surgical exposure of the permanent canine, the latter had erupted to the stage where labial tipping of the crown by an appliance was indicated. *Fig.* 10 shows the position after a further seven months, with the crown in place in the arch and the inclination of the tooth quite normal.

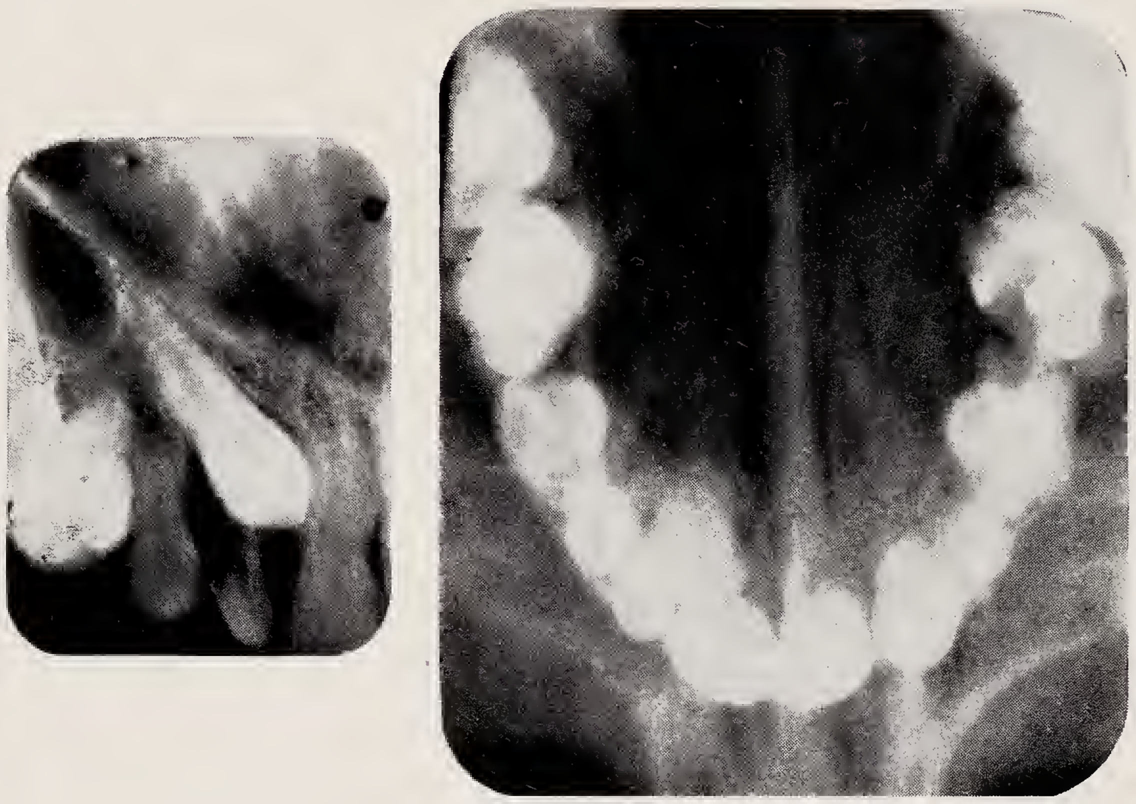

Fig. 9.—Abnormal unerupted $\underline{3|}$ before treatment; good prognosis (15 years; patient B).

Fig. 10.—$\underline{3|}$ in arch, 11 months later (patient B).

Where the first requirement—an unobstructed path of eruption for the canine—can be achieved only by mechanical traction on its crown to tilt it away from adjacent teeth after surgical exposure, the prognosis is poorer. The appliance therapy required is likely to be lengthy and complicated, and attended by risk to the vitality of the tooth. This type of case is best left to the joint efforts of a competent oral surgeon and a skilled and experienced orthodontist. When the crown of the canine is very deeply buried, the limiting factor may well be the surgical, rather than the orthodontic, difficulty.

Fig. 11 is an example of a case with a doubtful prognosis. The crown of the canine is tucked in very close to the root of the lateral, and its long axis is nearer the horizontal than the vertical plane. It cannot reach the surface unaided, and mechanical traction on the crown will be needed to obtain a more favourable line for eruption.

The second requirement—a normal position of the apex finally—is invariable. If an obstructed path of eruption is to be changed by tilting the tooth as described, allowance must be made for this when assessing the original apical position on the radiographs. Although tilting the tooth will not in itself move the apex a great deal, it will change the direction of the long axis and hence the path taken by the apex as the tooth erupts. If it is estimated that a normal position of the apex cannot be obtained either with or without this mechanical treatment, then the prognosis is hopeless.

Fig. 12 shows a canine which lies horizontally and crosses from buccal to lingual of the arch. The apex lies distally and buccally to the root of the premolar, and at an abnormally low level. Orthodontic treatment for this canine is useless.

Support for the adequacy of these criteria is provided by the views of Erikson (1938), Dewel, and Lappin, who all stress the marked tendency towards voluntary eruption of the canine, without any mechanical traction, given a freedom from obstruction.

the canine conforming to the criteria I have proposed.

Watkin (1947) drew attention in a case report to the path taken by the apex of an upper canine during orthodontic treatment by an appliance, as did Marsh (1948). The

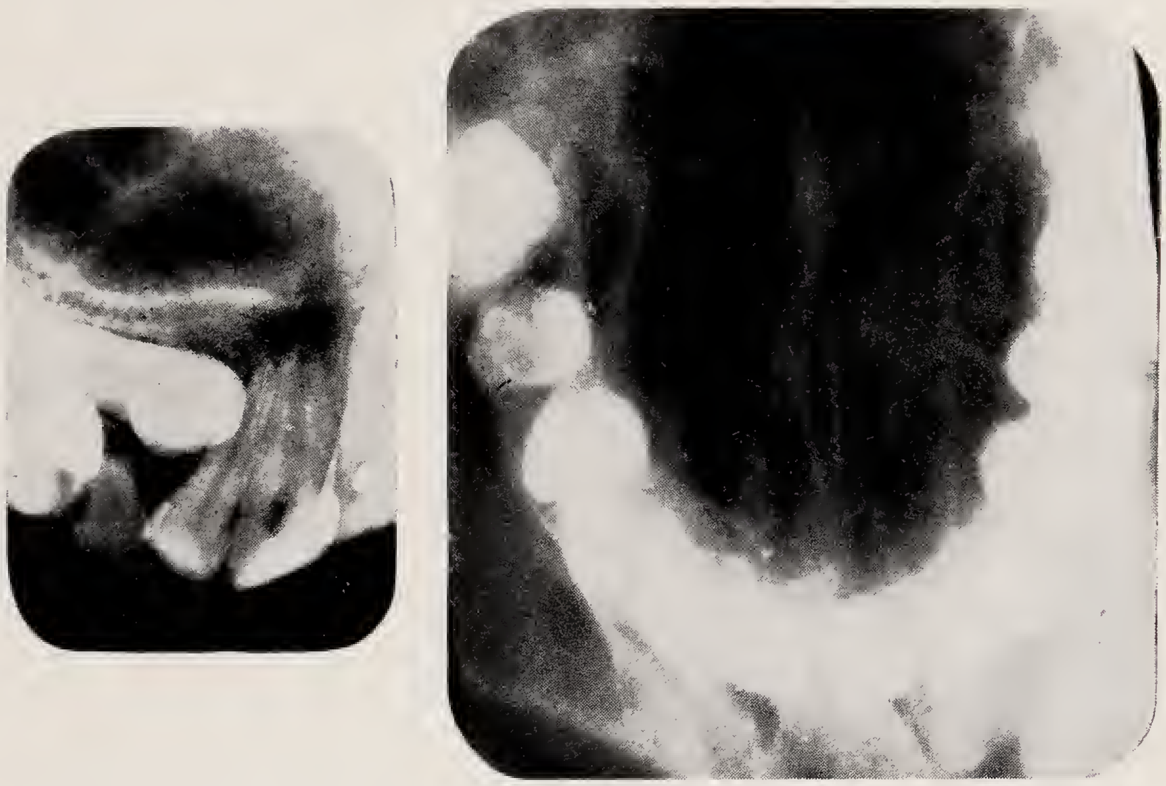

Fig. 11.—Abnormal unerupted 3|: doubtful prognosis ($15\frac{1}{2}$ years).

Fig. 12.—Abnormal unerupted 3|: hopeless prognosis (19 years).

Surprisingly, although the literature contains many case reports of malpositioned unerupted upper canines, the prognosis assessed prior to treatment is very seldom mentioned. It is perhaps significant, however, that an examination of the reproductions of radiographs accompanying the published successful cases almost invariably shows the position of necessity of starting with a favourable position of the apex of the canine was mentioned by Day (1951). Both Watkin (1936) and Stones (1954) have referred to the importance of the inclination of the tooth when considering treatment. Apart from these I can find little or no reference to the matter—doubtless it is one which the skilled orthodontist

considers almost subconsciously when assessing a case.

2. *Resorption of Deciduous Canine.*—I have discussed at some length the influence of the position of the unerupted canine in determining the prognosis for treatment to utilize this tooth in the arch. Another factor operating in these cases is the amount of root resorption of the deciduous canine when this tooth is retained.

The retained deciduous canine is often relatively unresorbed, and the alternatives for treatment then are: (*a*) Extract the deciduous canine and move the permanent canine into position; (*b*) Retain the deciduous canine and extract the unerupted permanent canine; (*c*) Retain the deciduous canine and leave the unerupted permanent canine undisturbed.

The choice of the appropriate treatment in a particular case is outside the scope of this paper, but some of the implications may be considered.

A retained deciduous canine may remain functionally useful for many years, but not infrequently such a tooth is shed in the second or third decade of life. The eventual resorption of its root follows loss of the vitality of the cementum, which is then unable to repair the progressive resorptions produced by adult masticatory stress (Kronfeld, 1932; Aisenberg, 1941). An artificial replacement for the canine is then needed.

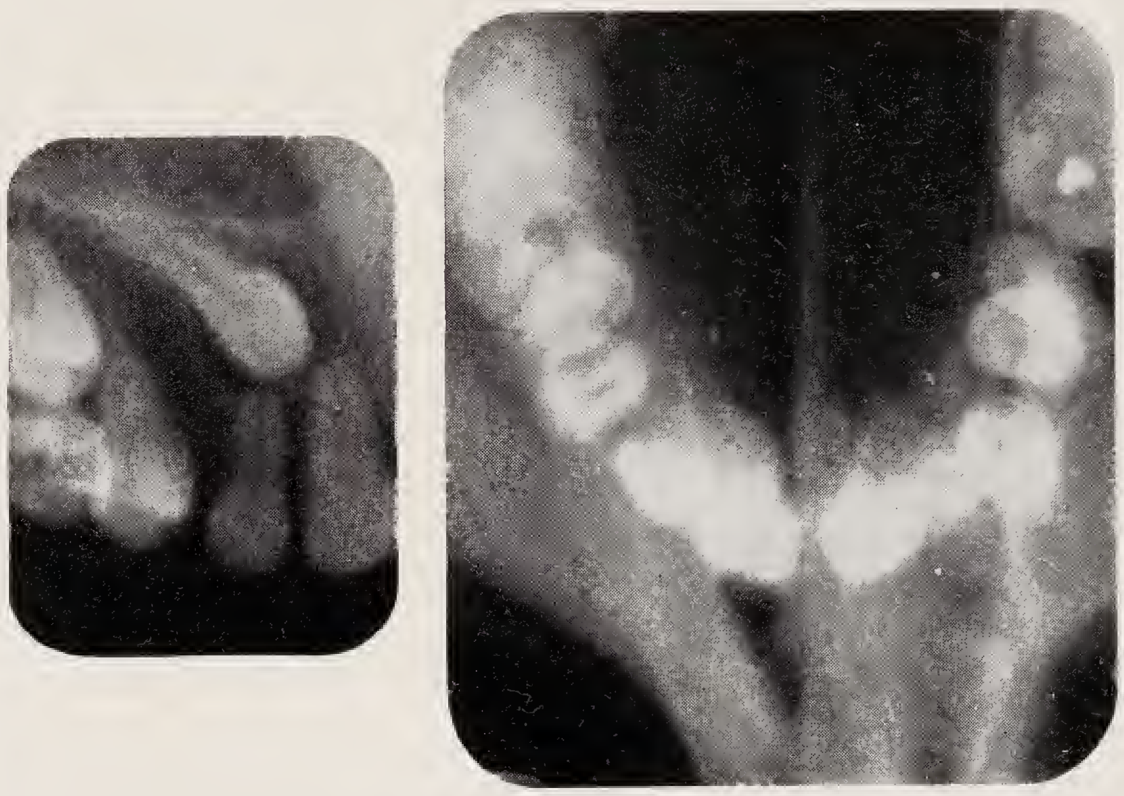

Fig. 13.—Abnormal unerupted $\underline{3|}$ in proximity to incomplete root of $\underline{2|}$ (11 years).

The decision whether or not to leave an unerupted misplaced canine in situ is governed particularly by the closeness of its relation to adjacent teeth. In later life it may start to move, and as its crown usually points mesially the root of the lateral or central incisor may be jeopardized, resorption being produced by pressure from the connective tissue follicle of the canine. Alternatively, the incisor may be pushed out of alinement.

Fig. 13 shows absence of the apical part of the root of the lateral incisor in a patient aged 11 years; the follicle of the unerupted canine lies over the blunted root end of the lateral. At this time the lateral gave a normal vital response to thermal stimuli, and there were no symptoms.

Occasionally an unerupted canine is responsible for referred pain of a neuralgic type—a number of such cases were reviewed by Nodine (1944), and Watkin (1947) described a case. In young patients there is a possibility of dentigerous cyst formation around the crown of an unerupted tooth.

Nevertheless, a completely unerupted canine may remain symptomless for very many years, and the possible complications resulting from its surgical removal might do more harm than good. Chapman (1949) reported a case where

an unerupted maxillary canine had produced no symptoms or damage to adjacent teeth in a man aged 75 years.

3. *Age of Patient.*—The age of the patient is a factor of some importance when treatment is contemplated to restore an unerupted misplaced canine to the arch. Following surgical exposure, a canine with an unobstructed path of eruption will erupt most rapidly and most completely where the surgery is carried out within a year or two of the normal eruption date. In an older patient, such as a young adult, the eruption of the canine is likely to be slower and less complete, necessitating a larger amount of mechanical therapy. This emphasizes the value of early recognition of the condition.

CONCLUSIONS

It will be seen that the assessment of prognosis for the unerupted misplaced maxillary canine can be made with a considerable degree of accuracy. It is based primarily on an adequate radiographic examination. Applying the criteria suggested and having regard to the other factors mentioned, logical reasoning will then indicate the appropriate line of treatment and its probable outcome.

A clearer understanding of what can, and what cannot, be done for buried canines should go far to ensure that patients are not subjected to extensive mechanical therapy unnecessarily, or unavailingly.

My thanks are due to the Department of Medical Illustration, United Manchester Hospitals, for production of the illustrations from the original radiographs, and to several of my colleagues at the Turner Dental School for helpful advice during the preparation of this paper.

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DISCUSSION

Mr. Kettle said he thought that an accurate estimation of the prognosis for the successful eruption of an upper canine into a satisfactory position was very difficult indeed. The most significant factor in determining the position of the unerupted tooth, when it was not presenting as a visible bulge and not palpable, was the position of the upper lateral incisor. He said it was difficult to assess by X rays alone whether the canine was lying palatally or buccally to the dental arch. Where the canine was lying buccally to the root of the lateral, the crown of the lateral was often tilted forwards and the apex of its root displaced inwards. Where the canine was on the palatal side of this tooth a retroclination of the crown of the lateral incisor was usually observed. The primary clinical examination should be followed up with stereoscopic X rays of the palate which do not necessarily require any complicated apparatus for their proper interpretation. He was not very happy in the cases shown by Mr. Hartley about the emphasis which had been laid upon treatment by simple surgical exposure and leaving the tooth to erupt unaided. He thought that this line of treatment would lead to quite a number of disappointments, because the canines are often impacted against the adjacent teeth and are not always able to erupt without assistance. Mechanical traction with an orthodontic appliance is often required or a zinc oxide pack must be inserted to prevent the healing of the palatal mucosa in the path of the eruption of the tooth. Dense bone tends to form around the crown of a canine which is disturbed by surgery and then left in an impacted position without further treatment.

Mr. Hovell said that he agreed with everything that Mr. Hartley had said about the position of the crown and apex of the upper canine. He thought its axial inclination had got to be studied. He thought there were one or two factors which ought to be brought out in the treatment of the palatally misplaced canine. He said he laid down certain criteria which had got to be followed during treatment. First you must make room for it in the dental arch. This could be done by closing up spaces in the incisor teeth or removing the first premolar. If the first premolar is extracted this often converts the bringing down of the canine to a much easier procedure. Secondly, the surgical exposure must be adequate; it is no good making a little hole in the palate, saying you have exposed it. Adequate bone removal should be made without damaging the adjacent teeth. Thirdly, it is essential in almost all cases to keep

the hole patent following the surgical exposure. If these criteria were carried out he had yet to see a canine in the palate which would not come down without mechanical traction.

Mr. Watkin said he appreciated the paper very much, but Mr. Hartley had not been dealing with treatment but diagnosis and he agreed with everything he had said.

Mr. Ballard said he agreed with all that Mr. Hartley had said and in particular with the fact that he said how difficult it was to assess the position of the canine from the intra-oral films. He said that at the Eastman Dental Hospital they had sought another way of assessing canine position, and they now took as routine a lateral skull picture, and a P–A, not necessarily in a cephalostat. He showed some slides to illustrate his point.

Mr. Norman Gray said that Mr. Hartley had classified and presented these cases in a very clear way. With regard to the problem of the X-ray procedure he liked to take an occlusal picture vertically through the long axis of the incisors, which entailed with the ordinary X-ray machine a tremendous exposure of at least 16 seconds. He thought this was a good way of demonstrating the position of the canine relative to the incisors.

With regard to the actual operation, he wanted to emphasize the necessity of wide exposure of the crown of the unerupted tooth. The surgical pack should be applied under pressure opposite the side towards which you wanted the buried tooth to move, thus encouraging the tooth to move in the right direction; when the pack is replaced the same thing repeated will often greatly facilitate eruption in the desired direction.

Mr. Chapman said he would like to raise one point that had worried him a number of times and that was the position of the apex of a more or less horizontal upper canine relative to the premolars. He found this an exceedingly difficult thing to diagnose from X rays: could Mr. Hartley give any help on this point?

Mr. Walpole Day said that it was primarily a paper of clinical assessment. He hoped one day one would be given on treatment. There was one point that had not been touched on at all and that was the question of vitality of the unerupted tooth. During the war a lot of work was done in Birmingham on the effects of cements on the dental pulp. He had to provide the teeth which were used, most of which were $\underline{4|4}$ which were destined to be extracted for orthodontic treatment and $\underline{5|5}$ which had erupted into the palate. Professor Manley found that the canines and premolars in the palate that were given him were useless because in the majority of cases they showed reticular atrophy of the pulp. He said it had been suggested that where a tooth is delayed, the delay caused atrophy of the pulp. He wanted to know whether Mr. Hartley had had any experience of this in unerupted canines in a child of, say, 13 or 14. He said that he had experienced this in central incisors that had been delayed and had observed differences in the colour between them where one was delayed. He would like to hear Mr. Hartley's observations on this point.

Mr. Pringle said that he thought the unerupted canine was one of the most difficult problems that the orthodontist came up against. He said that he still saw a number of unsuccessful cases where rather heroic treatment had been attempted to bring canines into the arch. He said that as one got older one got less heroic. He thought Mr. Hartley had sounded a note of warning.

Mr. Hartley said he entirely agreed with Mr. Pringle. One of the intentions of the paper was to discourage people from being too heroic.

Replying to Mr. Kettle he agreed that the tilt of the upper lateral could be an important diagnostic feature. He omitted that from his paper because he thought that there were others which were more commonly found. He felt that the radiographs could not fail to give the information required if they were taken from the right directions. Mr. Kettle had disagreed with this, saying that it was difficult to assess the labiolingual relation of the canine to the lateral incisor by means of X ray. The occlusal film exposed with the X-ray tube in the long axis of the upper incisors specifically overcame this difficulty. He had attempted to lay stress upon the simpler types of case because they were the ones for which we were able to do most. In the matter of zinc oxide packs which Mr. Kettle mentioned, he had deliberately omitted reference to this detail of treatment, because by "surgical exposure" he implied the use of any such technique which gave adequate exposure of the canine crown and maintained the opening during healing.

Mr. Hovell had remarked particularly about treatment, but he (Hartley) had purposely excluded from his paper considerations of treatment except in terms of broad principles. Had he included detailed treatment he would certainly have agreed with Mr. Hovell. He would like to add a word about mechanical traction to which Mr. Hovell had referred. Mechanical traction was not primarily to pull the canine down but to tilt it away from other teeth so that it would then have an unobstructed path of eruption and could be left to follow that path to a greater or lesser extent.

He thanked Mr. Watkin for his remarks.

Mr. Ballard had raised the point of taking one's own X rays. Certainly positioning of the tube and film was extremely important in this particular type of case. He thought that the choice of intra-oral or extra-oral films depended on one's personal preference. The use of postero-anterior and true lateral radiographs to supplement the intra-oral films described was mentioned in current textbooks.*

Mr. Gray had mentioned the subject of classification. He (Hartley) was not really trying to suggest a new classification for unerupted canines—Adamson had already presented quite a good one.† He had covered Mr. Gray's point about the occlusal picture taken through the long axes of the upper incisors. He thanked Mr. Gray for his helpful comments on the surgery required and said there were a number of techniques which had been advocated.

Mr. Chapman had spoken of the relation of the apex of the canine to the premolars. In a favourable case the apex of the canine would be in the line of the arch buccolingually as seen on the occlusal film, and well above the level of the premolar apices on the periapical film. In the case he showed as having a hopeless prognosis with the canine lying horizontally and crossing from buccal to lingual of the arch, its apex lay buccally to the root of the premolar and the crown lingually to the central and lateral incisors.

He thanked Mr. Walpole Day for bringing his attention to the observations of Professor Manley on reticular atrophy of the pulp in cases of unerupted teeth. Unfortunately he had no personal experience of this.

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ANGLE'S CLASS III MALOCCLUSION

By **S. G. McCALLIN,** L.D.S. R.C.S. (Eng.), D. Orth.

This paper on Class III malocclusion contains no original research, but will be an attempt to present an approach to diagnosis and treatment which is the result of clinical observation of fairly large numbers of patients in this category that have received treatment at the Eastman Dental Hospital in recent years.

Edward H. Angle, who did so much for orthodontics, said many things he would want to retract were he alive to-day. In his view if one moved teeth in malocclusion into what we know as normal occlusion as the result of mechanical interference, function would stimulate growth of bone to support the teeth so placed and facial harmony would follow as a result of this. While none of us believes this to-day we are, nevertheless, indebted to Angle for many things—not least his classification of malocclusion which makes it possible for me to discuss Class III cases without having to define them. His classification was entirely adequate for his purposes since he was convinced that one only had to place teeth in normal relationship to each other and they would remain stable.

In our search for the aetiology of malocclusion in general I believe that most of us approach the problem to-day from quite a different point of view. We believe that the dento-alveolar structures, as they grow from the dental base to meet across the intermaxillary space, are moulded by pressures exerted by soft-tissue posture and behaviour to bring the teeth into either normal occlusion or variations from the normal. Skeletal morphology and soft-tissue behaviour in any given case is, therefore, fundamental to the production of either normal or abnormal occlusion. Bearing this in mind it is possible to make a prognosis for treatment in most cases, and this applies to Class III as to other occlusal types.

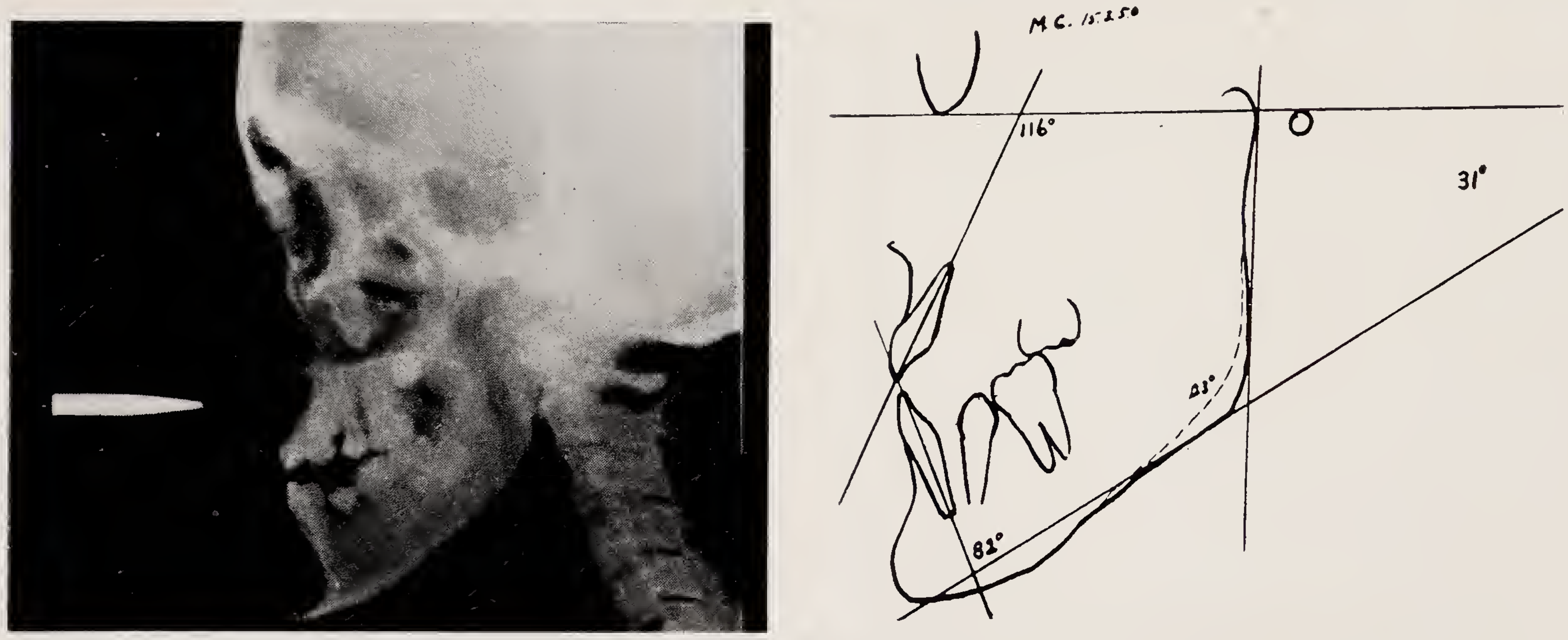


Fig. 1.—Lateral skull X-ray with tracing illustrating a Type I skeletal pattern in association with a Class III (Angle) malocclusion.

It is probably easiest to describe these cases in terms of the two extremes of morphological types observed, although a statistical analysis of cases would probably show a smooth distribution of variations between the two. Only by thinking in terms of the morphological characteristics of the two extremes can we approach diagnosis and treatment planning logically.

The first extreme type, which from here on will be referred to as Type I, has a characteristic skeletal pattern. The mandible is long, with a gonial angle which is above average. The maxilla is short anteroposteriorly and contracted laterally. There is usually a

Given at the Sheffield meeting held on May 6, 1955.

large intermaxillary space anteriorly. This space may or may not be completely spanned by the dentoalveolar structures. As a result of this skeletal morphology the face is long

Fig. 2.—Patient holding incompetent lips together by contraction of circumoral muscles, especially the mentalis muscle in the lower lip. She has a Class III (Angle) malocclusion on a Type I skeletal pattern.

and the middle third is concave in profile owing to the short maxilla (*Fig.* 1).

Associated with this skeletal pattern we observe soft tissues exerting pressures that produce occlusal variations that might be considered typical. Some of these occlusal variations will be described below, but first let us consider the soft-tissue morphology and behaviour most commonly seen.

We often find the tongue in resting posture in the floor of the mouth in association with a hyoid bone which appears in lateral radiographs to be below average level. The tongue is at rest in this position frequently with the posterior oral sphincter closed, the dorsum of the tongue being in contact with the soft palate. It is, however, found in this position in association with incompetence of the anterior and posterior oral sphincters when the patient will be mouth breathing or supplementing nasal breathing with oral breathing (Gwynne-Evans and Ballard, 1947).

Competent lips are seen in association with this type of skeletal morphology, but frequently a degree of lip incompetence is observed. It is not surprising that lips of average size do not come together in resting posture in these long-faced individuals, and this means that during function to close the anterior oral sphincter the lips tend to exert a firm pressure against the upper and lower labial segments of the dental arches (*Fig.* 2). Another morphological type of lip incompetence observed is one where the tissue of the lip is adequate for lip competence to be expected, but the lower lip hangs away from the lower incisors rather in the way that the lower lip is everted in the typical cleft-palate profile. This type of lower lip normally exerts little or no pressure against the lower labial segment.

To return to the tongue for a moment, one sees patients with this type of abnormal skeletal pattern who thrust their tongues between the upper and lower incisors at the moment of deglutition as described by Rix (1946). This behaviour pattern, together with the other soft-tissue variations I have mentioned, produce occlusal variations as follows.

Crowding of the teeth in the maxillary arch as the result of the short and laterally contracted maxilla is a common occlusal variation met with (*Fig.* 3). This crowding may be further complicated where the tongue adopts a low resting posture, as the maxillary dento-alveolar structures are free to contract on the dental base still further. Since the intermaxillary space is often above average the dento-alveolar structures are deep, so that the tongue is possibly never in contact with the hard palate and the maxillary dental arch fails to be moulded laterally. The mandibular arch is, however, moulded laterally, and since the dental base is large a typical wide and rounded arch is produced. These wide lower arches in association with narrow uppers result in unilateral or bilateral crossed bites, depending on the degree of discrepancy between the two arches.

Unilateral crossed bite is frequently associated with lateral displacement of the mandible to one side or the other as a result

of occlusal interference. This displacement becomes spontaneous, so that the mandible moves from rest position into occlusion smoothly without hitting the occlusal interference *en route*.

Just as low tongue posture can produce an unusually wide lower arch, so can it produce dental base, lip tongue balance being such that the lower labial segment is held lingually inclined so that the lower incisors are in a fairly normal over-bite relationship with the upper incisors and the upper and lower buccal segments are in good relationship. Anterior oral incompetence where the lips in function

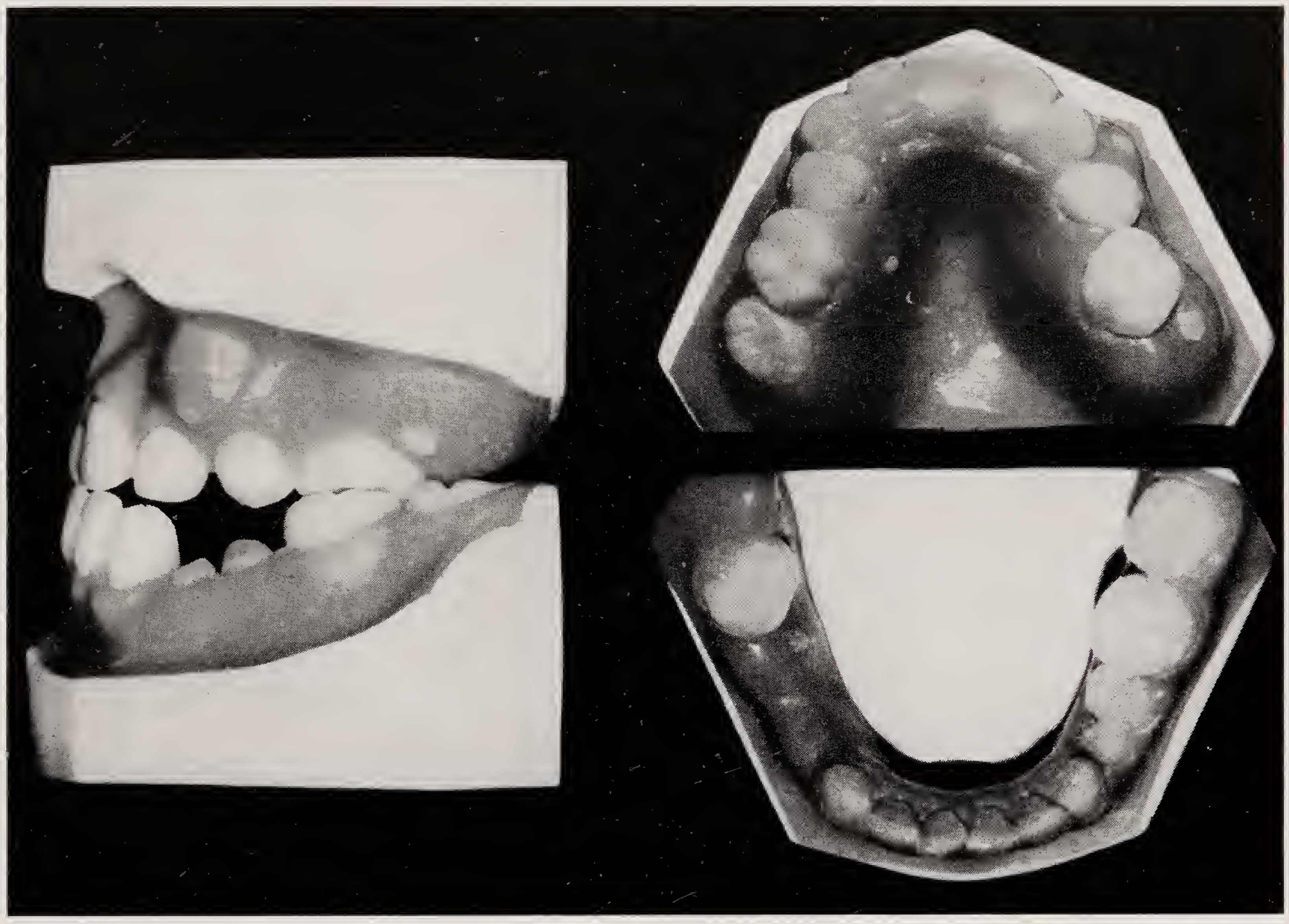


Fig. 3.—Models of a Class III (Angle) malocclusion on a Type I skeletal pattern. Relatively poor development of the maxilla has resulted in displacement of $\underline{5|357}$ from the upper arch. In the lower, early loss of deciduous teeth and $\overline{6|}$ from the buccal segments has resulted in collapse of the lower labial segment.

an unusually long one, and the lower labial segment may be separated from the buccal segments. This happens when this tongue posture is associated with a mandible having an unusually long body, and it means that the buccal segments of the lower arch play no part in supporting the lower labial segment from lingual collapse.

The forward pressure of a tongue postured in this way when the mandible is short can produce a Class III incisor relationship, while the dental base relationship is relatively normal.

Alternatively it is possible for soft-tissue pressures to produce a fairly normal occlusion on a high-gonial-angle type of Skeletal III exert a firm pressure against the labial segments and the tongue is not held in the floor of the mouth would bring about this type of occlusion.

A further occlusal variation that is the result mainly of skeletal morphology is an anterior open-bite. The dento-alveolar structures fail in their vertical development to span the intermaxillary space in the anterior part of the mouth. Frequently these patients can only occlude on two posterior teeth on either side, with the open-bite extending to the back of the mouth (*see Fig.* 1). A further type of anterior open-bite can be explained as being the result of an anterior tongue thrust at the

moment of deglutition, or possibly the tongue is postured between the upper and lower incisors at rest.

This mesial displacement is less commonly seen on this type of dental base than in the other type of extreme variation described below.

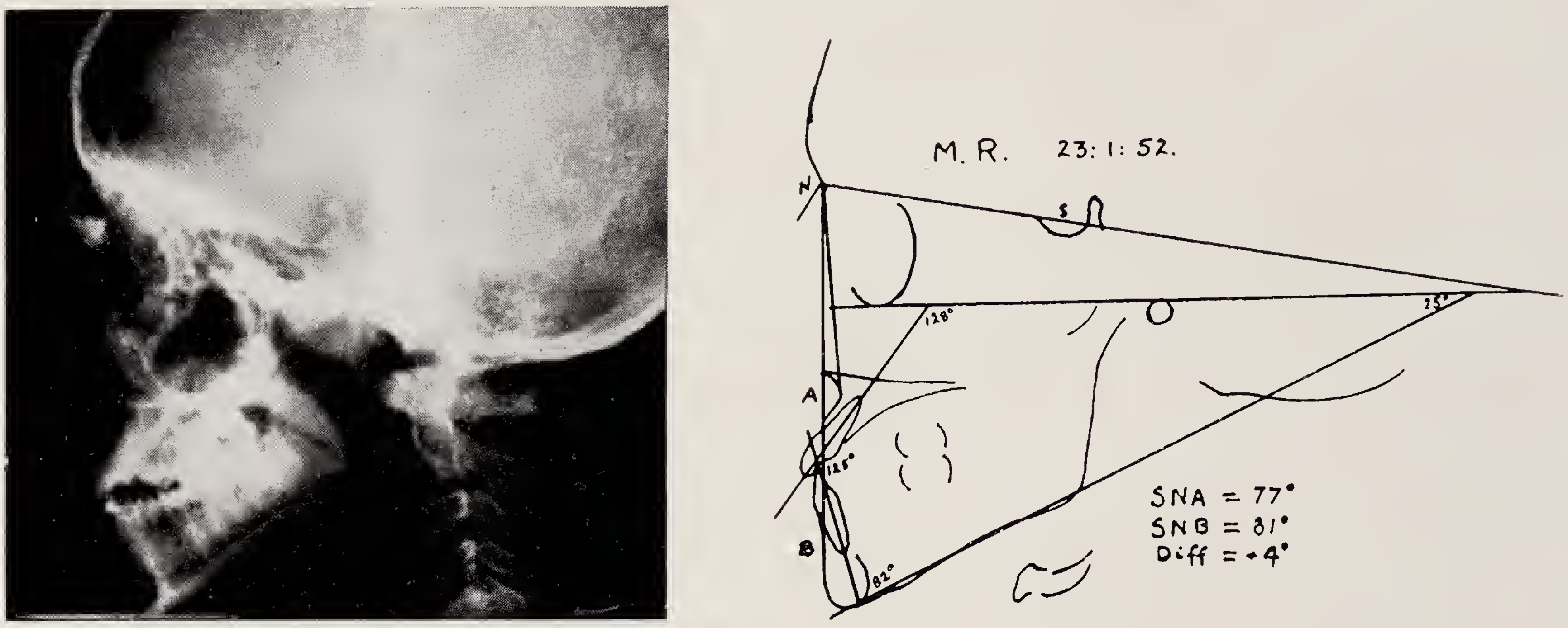


Fig. 4.—Lateral skull X-ray with tracing that illustrates a Type II skeletal pattern in association with a Class III (Angle) malocclusion. Cases are occasionally observed where the anteroposterior length of the maxilla places the apex of the maxillary incisors farther forward, so that the angle between the long axes of the upper central incisors and the Frankfort plane more nearly approximates the average of 107°.

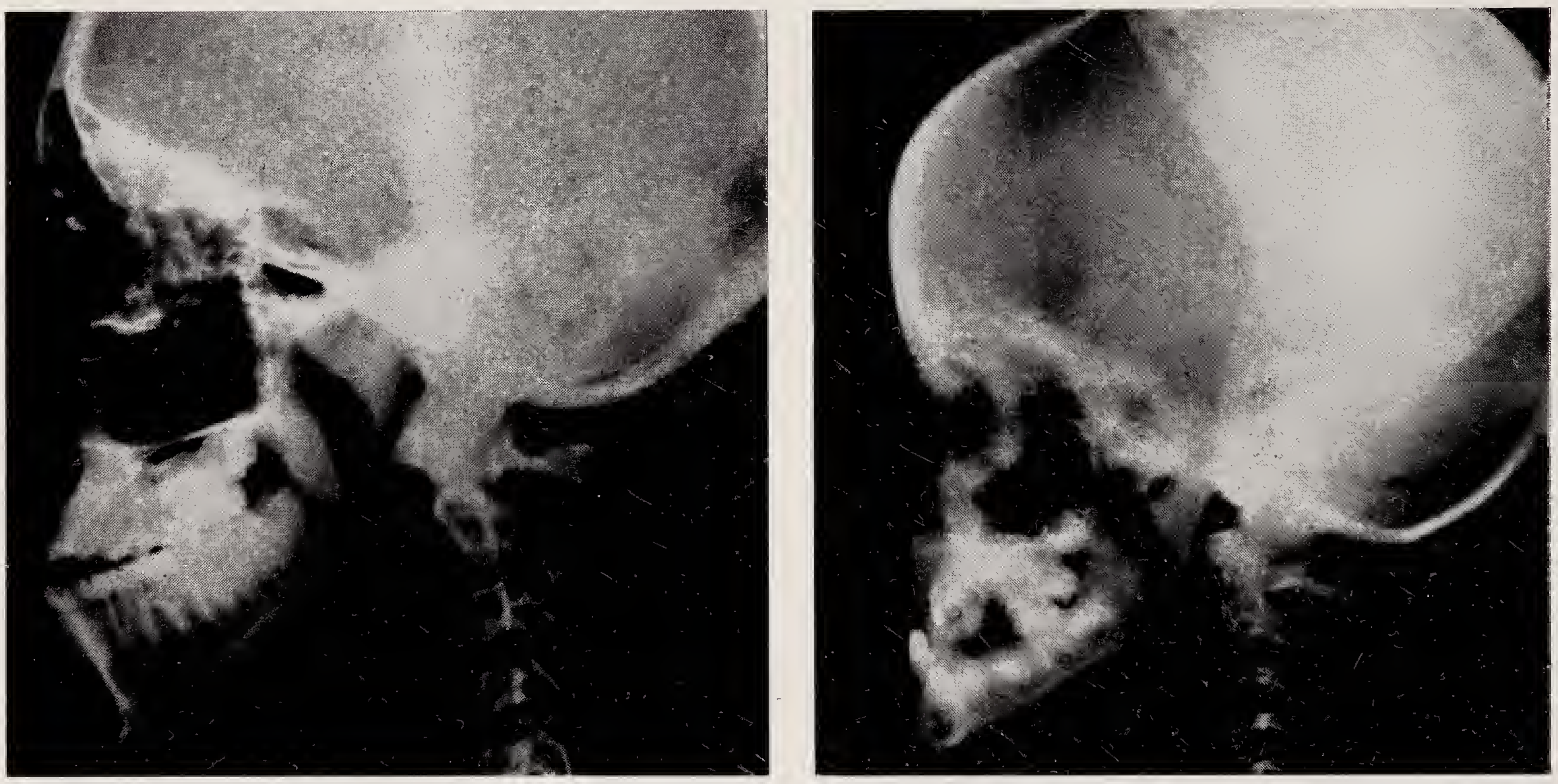


Fig. 5.—*Left*, Lateral X-ray of Class III (Angle) malocclusion on an intermediate type of skeletal pattern where the maxilla is well developed anteroposteriorly and the Frankfort mandibular plane angle is 42°. There was room for all the teeth in the maxillary arch without crowding. *Right*, Lateral X-ray of a Class III (Angle) malocclusion on an intermediate type of skeletal pattern where the maxilla was exceedingly short anteroposteriorly and contracted laterally in association with a mandible with a low gonial angle and a small Frankfort mandibular plane angle of 26°.

One further occlusal variation that should be mentioned in association with Type I skeletal patterns is a mesial displacement of the mandible that is the result of premature contact between the incisors as the mandible is moved from rest position into occlusion.

Now the other extreme morphological type, which from now on will be referred to as Type II, might be described as follows: the body of the mandible is long but the gonial angle is average or below average, and this is associated with a maxilla that is of average

length anteroposteriorly and not contracted laterally. This maxillary development means that the degree of mandibular prognathism is less marked than in the cases on Type I skeletal patterns. The intermaxillary space is about average and these patients tend to have round or square faces (*Fig.* 4).

I do not propose to go into the mechanism whereby the mandible is displaced mesially as a result of incisor interference since this has been discussed elsewhere, but it must be mentioned at this time since it is the commonest

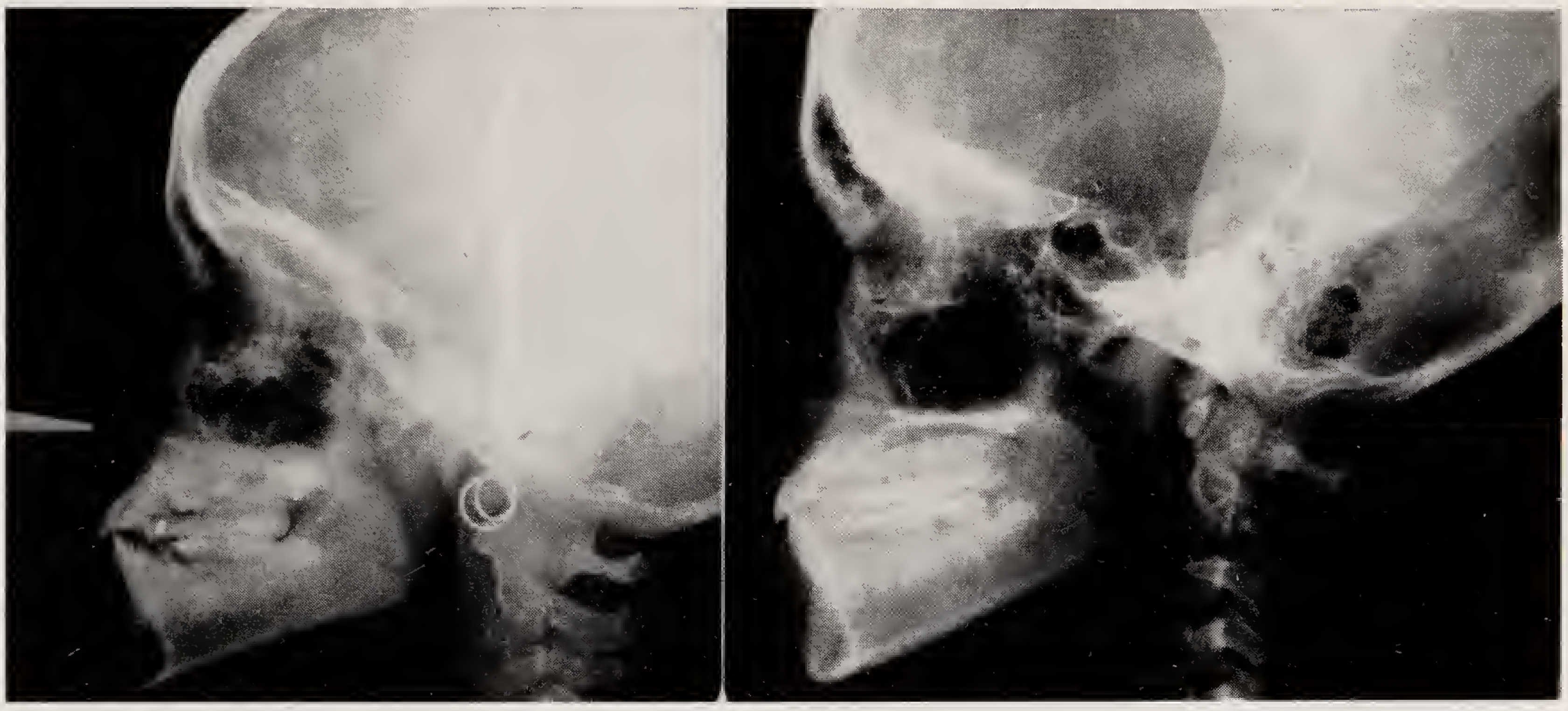


Fig. 6.—Illustrates considerable growth of both the dental base and dento-alveolar structures between the age of 9 years 2 months and 14 years exactly. The skeletal pattern originally was an intermediate type Class III.

Passing to soft-tissue variations, I think it is true to say that there are no typical muscle abnormalities whether of behaviour or posture that can be said to be regularly found in association with this type of dental base. The occlusal variations are, therefore, almost entirely the result of the skeletal pattern and, when the skeletal pattern does not vary greatly from the normal although the above characteristics are present, it is possible for a reasonably normal occlusion to result. It is not, however, uncommon to find that as the result of incisor interference the mandible is displaced mesially, so that the lower incisors are free to over-crupt to some extent. At the same time this displacement results in a partial over-closure, so that when the mandible is in rest position the inter-occlusal space in the posterior part of the mouth is wider than normal. This can probably best be explained on the ground that as a result of the over-closure the dento-alveolar structures in the posterior part of the mouth are not free to erupt to fill the intermaxillary space normally.

occlusal variation found in association with this type of skeletal morphology in Class III cases.

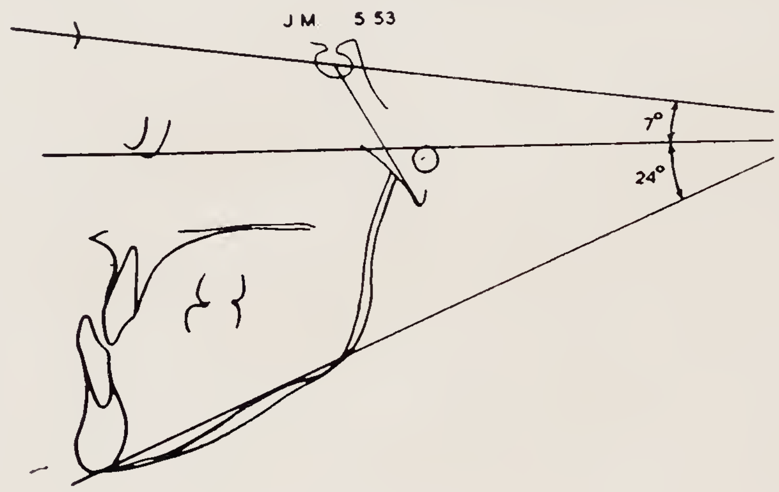
Between these two extreme types of skeletal morphology fall the great bulk of Class III cases that we see, and they are the result of the interplay between the skeletal pattern and soft-tissue behaviour and posture presented in each individual case, and, naturally, a wide variety of occlusal variations result. It is not possible to say that there is any one particular intermediate type that is seen more frequently than any other. Two intermediate skeletal types observed are illustrated in *Fig.* 5.

Before passing on to treatment one should mention that we occasionally see intermediate types of Class III cases where a study of serial radiographs suggests that bone growth is taking place at a greater rate than normally. The basal structures seem to grow forward relatively more rapidly than the cranial base so that bimaxillary prognathism becomes more marked. We have not observed cases where the mandible grows forward more rapidly than the maxilla so that mandibular

prognathism alone increases. A study of orthodontic text-books suggests that this relative increase in mandibular prognathism is frequently observed. We, however, cannot confirm this (*Fig.* 6).

Our approach to treatment is based on the principle that orthodontic treatment does not change dental base relationship and that soft-tissue patterning, while it does change, is somewhat unpredictable and may or may not be modified as the result of treatment. In Class III conditions where an over-closure factor is present, there is a change in the relationship of the mandible to the maxilla in centric that results from reducing the displacement, but we cannot demonstrate that it is possible to move a mandible mesially or distally as the result of orthodontic interference (*Fig.* 7). I do not mean by these remarks that we feel that we are in a position to be dogmatic about this but, for clinical purposes, this approach to the problem seems to be justified. When we come to soft-tissue behaviour we would be very unwise to be dogmatic, but the amount of change we can hope for as a result of our attempts to educate or modify it is possibly very small. It is true that patients can, by application and enthusiasm, overcome lip incompetence by teaching themselves to voluntarily hold their lips together and, when this happens, incisor relationships change, but patients are observed who have been able to do this for a time, gradually reverting to their fundamental behaviour patterns later in life and, as a result of this, incisor relationships changing back to what they would have been if the patients had never succeeded in compensating for their muscle abnormality. I think it is true to say that patients are less able voluntarily to control variations of tongue behaviour than they are lip posture and behaviour, and this fact, together with our inability to change dental base relationship, imposes considerable limitations on what we can do by orthodontic treatment for many types of Class III malocclusion.

Usually treatment required to overcome occlusal variations in Type I cases is a reduction of crowding in the upper arch related to the small maxilla and the need to take the lower labial segment lingually so that it is placed normally behind the upper labial segment. The old empirical treatment for these cases which involved proclination of the upper labial segment, expansion of the upper arch, and Class III intermaxillary traction seldom produces a stable end-result. The proclined upper incisors will either collapse



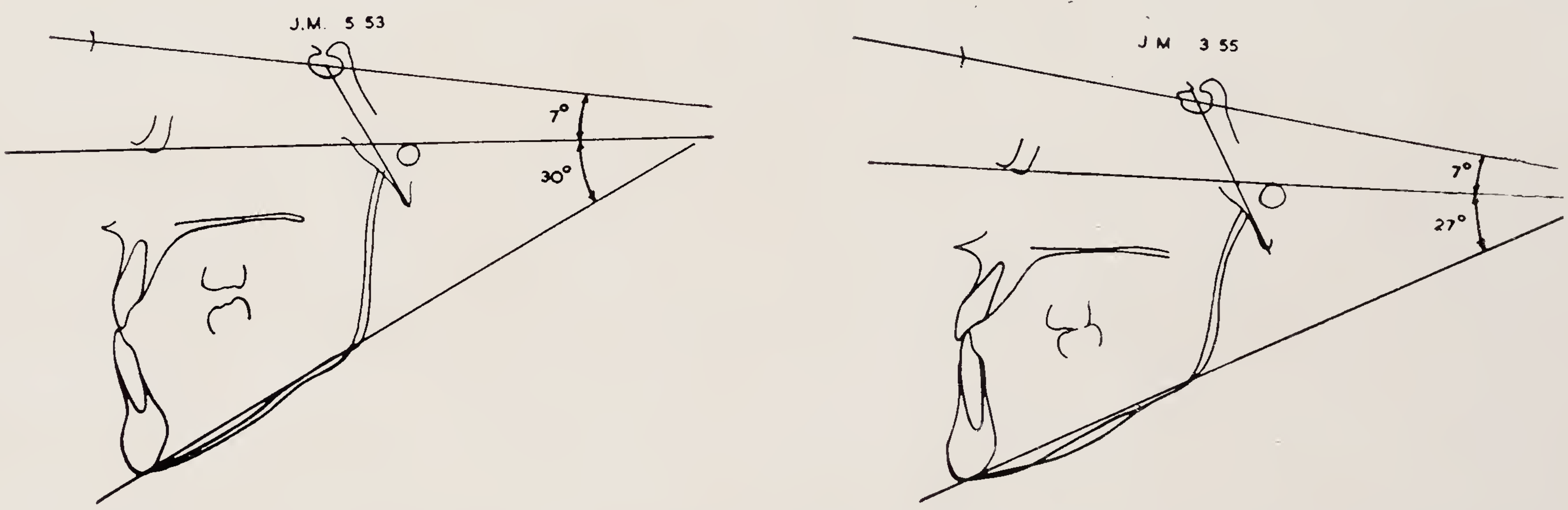


Fig. 7.—Illustrates the changes that have taken place in the skeletal pattern as a result of eliminating an over-closure factor as the result of orthodontic interference. There has been no change anteroposteriorly in the relationship of the mandible to the maxilla from its original rest position to the one found after treatment.

owing to firm lip pressures and inadequate basal support or, if they should grow down over the lower incisors so that these teeth prevent them from dropping palatally, a displaced laterally off the dental base. It has been found from a study of many Class III cases treated in this way that maxillary expansion seldom remains stable. Arising

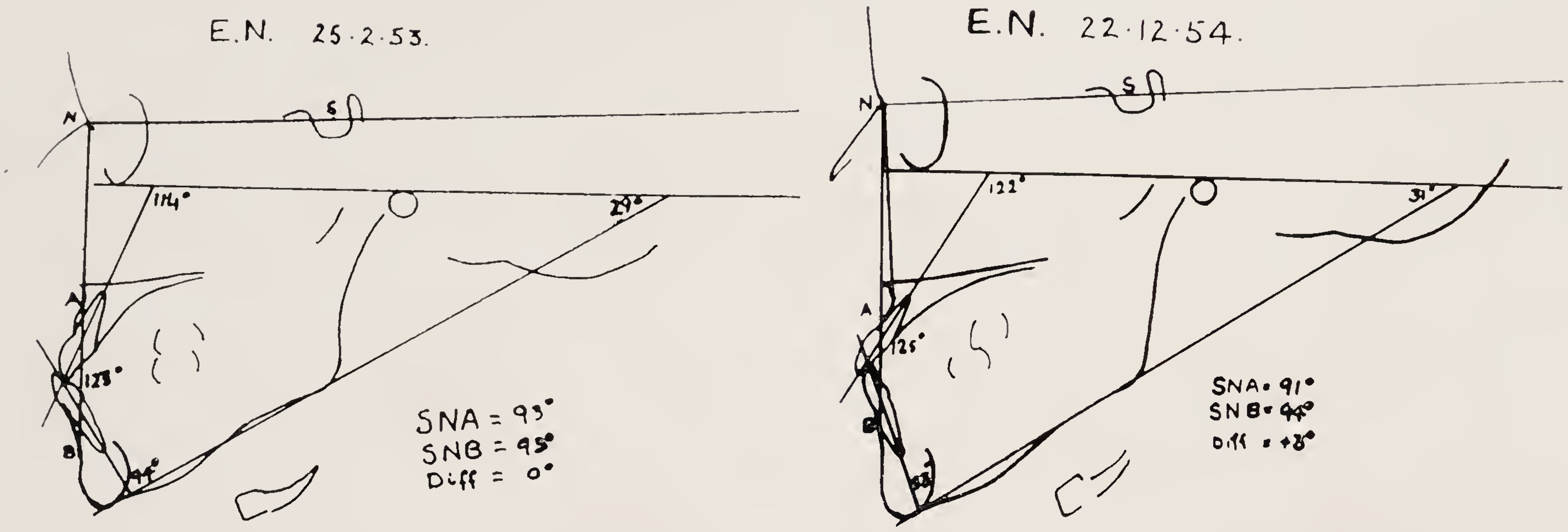


Fig. 8.—Tracings of lateral skull X-rays of a patient with a Class III (Angle) malocclusion on an intermediate type of skeletal pattern before and after treatment. There was a slight over-closure factor. Considerable tipping of the upper incisors labially and the lower incisors lingually resulted from treatment. $\overline{4|4}$ were extracted. The incisors remained clinically loose after appliances were removed.

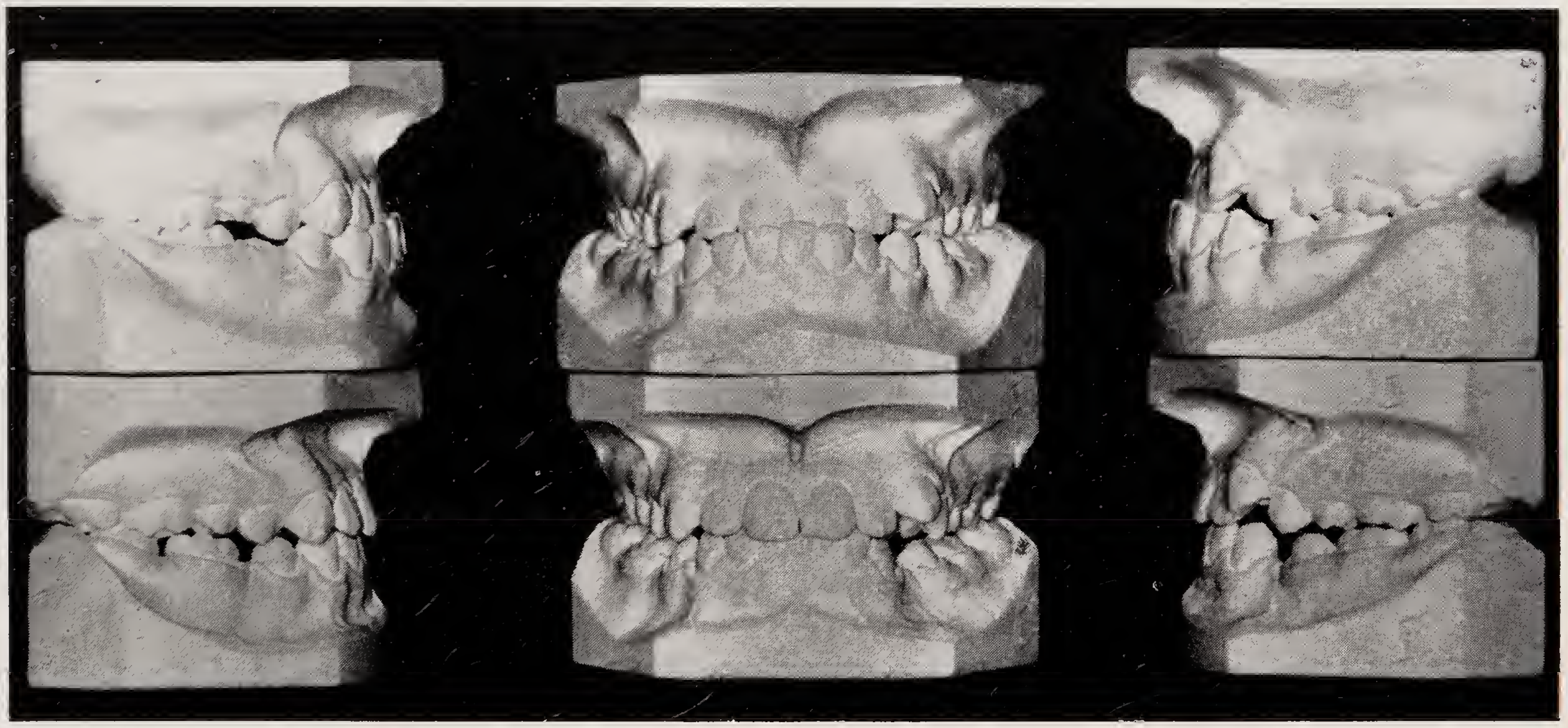


Fig. 9.—Models of case shown in *Fig.* 8 made on the same dates as the lateral skull X-rays were obtained from which tracings in *Fig.* 8 were taken. Although the position of the incisors has been improved æsthetically, their relationship is traumatic and the extraction of a tooth from the upper left buccal segment is probably contra-indicated for fear of losing the support of this buccal segment for the upper incisors which muscle pressures are attempting to position farther lingually.

traumatic incisor relationship will result. Expansion in the maxillary arch does not result in growth of the basal structures and, since we so frequently find the tongue postured in the floor of the mouth, there is seldom soft-tissue pressure on the lingual side of the upper teeth to hold the buccal segments from this it seems inevitable that the only possible treatment for crowding in the maxillary arch is the extraction of teeth and, if we are going to be successful in placing the lower incisors inside the uppers, these teeth must be tipped lingually and, to do this, it is almost invariably necessary to extract lower

premolars. If the tongue is postured in the floor of the mouth and we extract from the lower arch, we can only hope to retract the lower incisors the amount that they are supported by the lower buccal segments. This means that we frequently cannot use space equivalent to a full premolar for the retraction of the labial segment because the tongue will only permit a few degrees of lingual tilt and we are left with residual spaces. Our problem, then, is exceedingly difficult. Soft-tissue pressures frequently prevent us proclining the upper incisors more than a degree or so, whereas the amount we can take back the lower incisors is something of an unknown quantity, and we must guard against producing an incisor relationship that is traumatic, which will lead to a gradual deterioration of the investing structures surrounding the incisors and, indeed, resorption of the roots of these teeth (*Figs.* 8–11). Prognosis, therefore, must be related to the degree of discrepancy

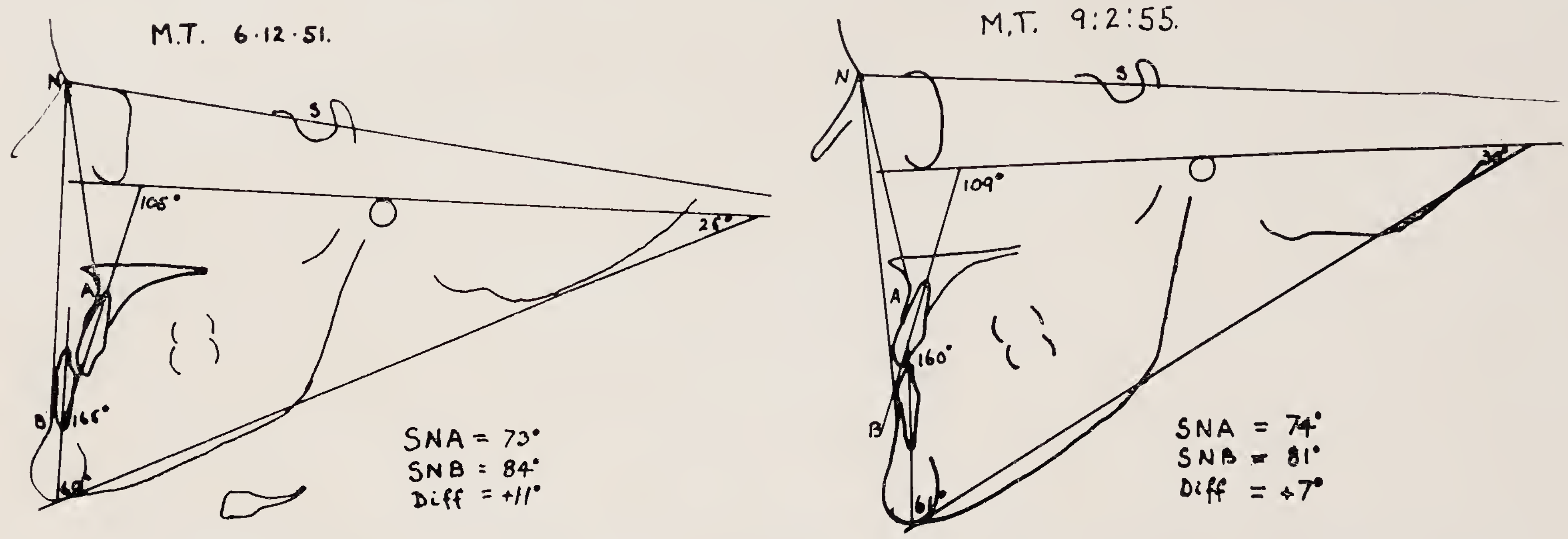


Fig. 10.—Tracings of lateral skull X-rays of patient with a Class III (Angle) malocclusion on an intermediate type of skelctal pattern before and after treatment. There was a slight over-closure factor. It was only necessary to tip the upper incisors labially a few degrees to overcome the mesial displacement of the mandible and the improved incisor relationship is not traumatic. $\frac{4|6}{6|6}$ were extracted.

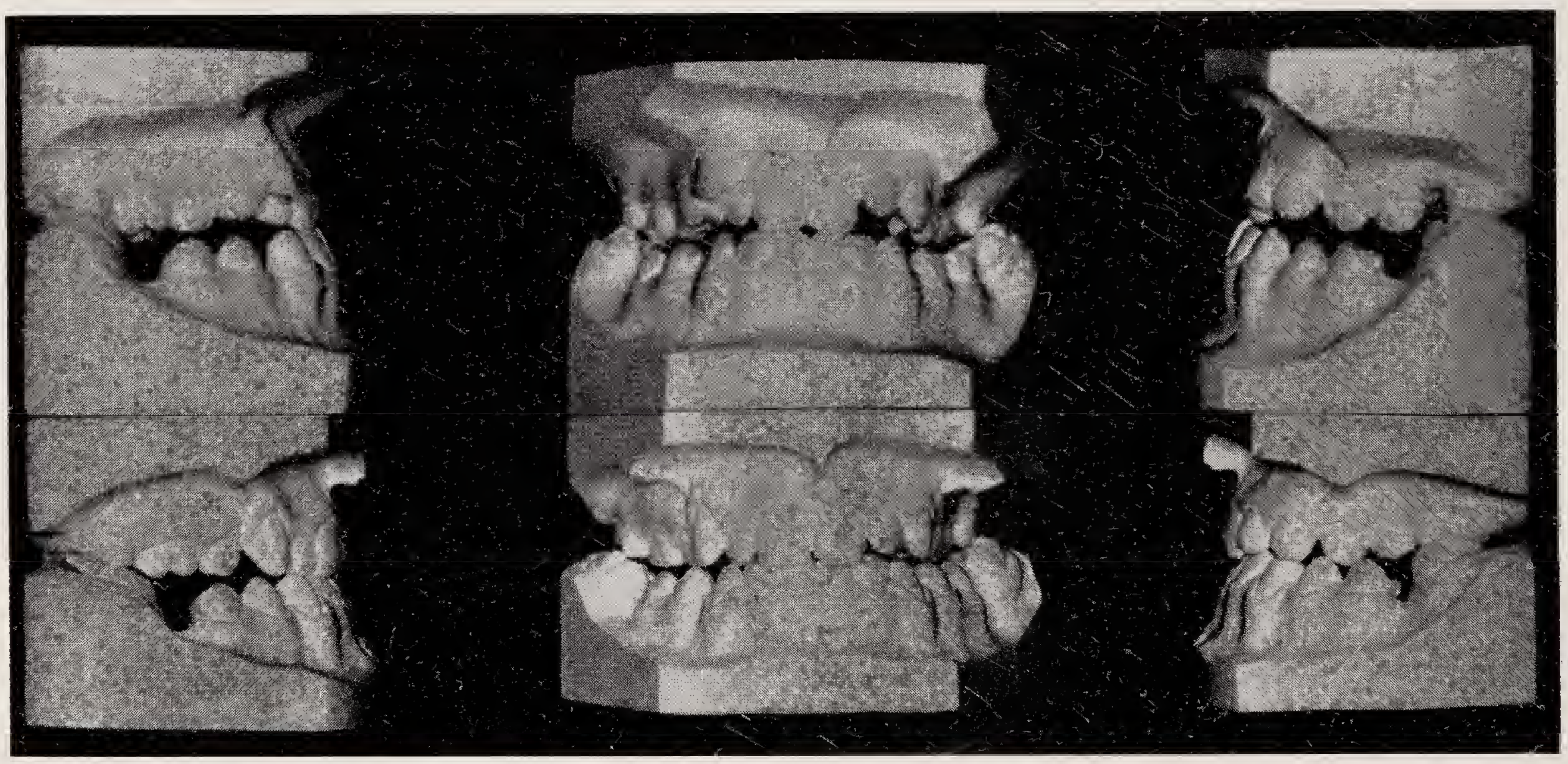


Fig. 11.—Models of case shown in *Fig.* 10. The upper models were made on April 4, 1951, and the lowers on May 29, 1953. Note that it was only necessary to tip the teeth in the upper labial segment forward a few degrees and that the upper buccal segments are supporting them. Incisors were clinically firm.

between the anteroposterior relationship of the upper and lower labial segments, this prognosis being worse as the discrepancy is more marked.

As I mentioned above, if the lower labial segment is not supported by the lower buccal segments as a result of skeletal and soft-tissue variations, the tongue being held in the floor of the mouth and the body of the mandible being long, extraction from the lower buccal segments cannot be expected to result in a retraction of the lower labial segment remaining stable, so that prognosis in a case of this type is very poor.

With the above generalizations about treatment in mind, I should like to end by describing some of the problems related to specific cases which might be taken as examples of a cross-section of Class III malocclusions that we see in practice. In the group of cases that fall roughly under the heading of Type I, the most common condition seen is maxillary crowding, with the lower labial segment placed in front of the upper labial segment with a unilateral or bilateral crossed bite. As I suggested above, expansion is rarely successful in those cases where the crossed bite is bilateral. In unilateral crossed-bite cases, however, especially if there is some lateral displacement of the mandible due to occlusal interference caused by a slightly contracted maxillary arch, it is possible, if a small amount of expansion is all that is necessary, to reduce the displacement and uncross the bite in this way. In the bilateral crossed-bite cases there is almost invariably crowding in the labial segment as well as the buccal segments, so that extraction from the maxillary arch is necessary to reduce incisor crowding. Since we probably cannot procline the upper labial segment to any great extent, extraction from the lower arch also is necessary and, if the incisor abnormality is not too exaggerated, appreciable improvement frequently results from the loss of the lower first premolars followed by a lingual tipping of the lower incisors. Residual spacing in the lower arch, for the reasons I have given, has to be reduced by bringing the lower buccal segments forward at the same time that the labial segment is taken back. Extractions from the lower arch with lingual tipping of the lower incisors does unfortunately leave the chin relatively more prominent in profile, which must be taken into account when deciding whether treatment is justified.

Where the lower labial segment is not in contact with the lower buccal segments in association with maxillary crowding, theoretically all that one can do is to reduce the maxillary crowding by extraction and place the lower labial segment farther back as a result of surgical interference. The difficulty with this procedure is that it tends to place the body of the mandible so far back if the incisor relationship is to be completely corrected that patients tend to acquire a somewhat chinless appearance, since you will remember that the middle third of the face is depressed in association with the small maxilla.

In those cases where a patient has an everted lower lip which is postured away from the labial surface of the lower incisors, extraction from the mandibular arch will result in our being able to hold these teeth farther back only if the patient can be persuaded to reduce the lip incompetence by holding the lower lip back against the incisors, and it is a fact that some patients do succeed in doing this. To what extent they relax later in life I am not prepared to say. So far as I am aware the long-term results of this have not been recorded. We have, however, seen cases where it has been possible to dismiss patients with greatly improved incisor relationships which appeared to be stable at the time.

In Type I cases we are sometimes faced with anterior open-bites with or without maxillary crowding which is the result of the deep intermaxillary space in the anterior part of the mouth, the patient only being able to obtain occlusal contact in the molar region. Experience has shown that it is difficult to elongate the upper and lower incisors to produce an over-bite as the result of mechanical interference. Usually the teeth just become loose and the further we attempt to move them the looser they become. When

this happens one is not justified in continuing treatment. It is a waste of time grinding the posterior teeth in an effort to allow the incisors to come closer together since the molars already fill the intermaxillary space and, as a result of the grinding, will simply

Fig. 12.—Illustrates a chin cap being pulled against the lower lip so that pressure is exerted against the lower incisors through the lip.

erupt a little further, so that the incisor relationship remains the same. Theoretically the extraction of a number of posterior teeth and placing dentures so short that they do not fill the intermaxillary space at the back of the mouth should allow the incisors to come closer together as a result of over-closure.

The other type of open-bite on Type I skeletal patterns was related to a tongue thrust during swallowing which held the anterior dento-alveolar structures from growing down to span the intermaxillary space. Almost invariably there is maxillary crowding in these cases so that extractions from the maxillary arch are necessary, and here if we extract lower premolars to enable us to take the lower labial segment back, the anterior open-bite increases as the reverse over-jet is reduced unless the tongue behaviour is modified. The prognosis for this is not good and these cases are not very amenable to treatment.

It is sometimes worth while taking a lower labial segment back at a fairly early age by using a headcap on traction to a chinstrap which is designed to exert a force through the lower lip against the lower labial segment. If the lower first deciduous molars are extracted it is frequently possible to retract the lower labial segment when the lower incisors are not too far in front of the uppers, and a marked improvement in their relationship can be brought about in this way. The extraction of the lower first premolars is envisaged at a later stage (*Fig.* 12).

The treatment of cases on Type II skeletal patterns where the Frankfort mandibular plane angle is less than average is easy or difficult in relation to the degree to which the lower incisors are placed labial to the uppers. As I said above, fairly normal occlusions with a reduced over-bite are encountered in this group, and the incisor over-bite is frequently the optimum that can be expected under the circumstances, and when this is the case an attempt to increase the over-bite is probably unwise.

If, however, the dental base relationship places the lower incisors well in front of the uppers and there is no mesial displacement of the mandible, extraction of two lower first premolars seldom permits us to tip the lower incisors back far enough to achieve a satisfactory incisor relationship, not only would the lower canines have to be taken bodily back for us to have space to tip the incisors lingually but the lower incisors would be unstable, to say nothing of being æsthetically unsatisfactory in that position. When this has been attempted it has also been found that it is impossible to close up residual spacing and that the lower second premolars fail to erupt to fill the intermaxillary space in the buccal region and remain in infraclusion. Prognosis then for the successful treatment of a pure Type II Class III case as the result of orthodontic intervention is poor, and here again surgery is the only answer in extreme cases. Fortunately this type of case is uncommon in this country.

If, however, there is a mesial displacement of the mandible as a result of incisal interference to the path of closure, theoretically one should attempt to take the lower incisors inside the uppers by moving these teeth lingually as much as possible rather than proclining the upper incisors. Associated with Type II skeletal morphology soft-tissue abnormalities are uncommon while the maxilla is relatively well developed, and it is therefore often possible to procline the upper incisors a few degrees and they will remain stable. What we must guard against is producing an incisor relationship that is traumatic as the result of over-proclinating the upper incisors which permits them to erupt so that the over-bite becomes deep enough for the lower labial segment to support the upper incisors farther forward than soft tissue related to the dental base will tolerate.

Fortunately many of these displacement cases are on relatively normal dental bases, so that a very mild proclination of the upper incisors is all that is necessary to reduce the displacement and produce a much improved incisor over-bite, and, since the amount of proclination is so slight, we frequently achieve a satisfactory result which is not traumatic.

Treatment of cases that present on the intermediate types of skeletal morphology can usually be approached logically if one bears in mind the two extreme types that I have described. It would be impossible in a paper of this kind to go into all the variations that we see. What I have tried to do is to focus attention on the need for careful diagnosis when considering the type of treatment that is likely to benefit Class III malocclusions and to point out why what one can hope to do for these individuals is usually little better than a compromise.

I am indebted to the staff in the Orthodontic Department of the Eastman Dental Hospital for allowing me to show cases from the departmental files and also to the Photographic Department for the preparation of the illustrations.

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DISCUSSION

Mr. Chapman: I am glad to open the discussion on Mr. McCallin's valuable paper; its reading gives one much to think about; its treatment of the subject includes what may be called the newer thinking in orthodontics—the effect of soft tissues on occlusion; the earlier paragraphs give the impression that these, the soft tissues, were to be predominant, but, proceeding, one learns that the osseous tissue remains the fundamental factor and that must be borne in mind all the time.

Whether the soft tissues are as important as the paper implies, I have some doubt; it would be interesting to know in what proportion of cases they are a factor in the aetiology of Class III and what harmful effects on occlusion are to be attributed to them. It is only in very recent years that such close attention has been given to the soft tissues, yet there must be many successfully treated cases prior to this period, so the conclusion is that they, the soft tissues, are a factor in a minority only.

Mr. McCallin states that "soft-tissue patterning, while it does change, is somewhat unpredictable and may or may not be modified as the result of treatment". The repositioning of the mandible, whether backwards or forwards, implies that the soft tissues will be enabled to assume their normal relations—a definite benefit and a point in favour of changing the dental base relation. This leads to a point of some importance—great importance—and here there may be some divergence of opinion between Mr. McCallin and myself; it concerns the statement in the paper that "orthodontic treatment does not change dental base relationship" followed by "I do not mean by these remarks that we feel we are in a position to be dogmatic about this but, for clinical purposes, this approach to the problem seems to be justified". I want to draw particular attention to these statements because their implication is fundamental from the point of view of treatment and I want to state emphatically my belief, based on clinical experience, that the dental base relation (or arch relation, to use an older expression) can be changed: at the close of my remarks I will show a few cases in support of my contention.

There are two other points I want to discuss: the first is the great degree of inclination and proclination of the upper and lower incisors, which is implied in the paper, to bring about their correct labio-lingual relations. I would not have expected it possible that such changes could be permanent; in fact, Mr. McCallin points out, when speaking of "the old empirical treatment for these cases" that the "proclined upper incisors will either collapse" or "a traumatic incisor relationship will result". Yet the retraction of the mandible reduces the degree of both these possibilities, important points in favour of this plan of treatment compared with that described in the paper, which includes the considerable proclination of upper incisors and lingual inclination

of lower incisors. A change in the relation of incisors to basal bone is very prominent in the treatment of many types of cases to-day and I often wonder how stable they are—for my own part I have always been diffident of making such changes. I hope Mr. McCallin will bring examples to our notice.

The second point concerns extraction. The majority of Class III cases have good arches: in a few the upper is somewhat small but not the lower, which has a dental base large enough to contain all the teeth, so as a principle it is not desirable to reduce the amount of dental tissue in the maxilla (this is in contradistinction to Class II cases in which it is undesirable to extract in the lower). It rarely serves a useful purpose to extract a lower tooth; loss of an incisor will not necessarily permit greater inclination of the remainder; loss of a premolar only permits the remaining teeth to be moved mesiodistally round the basal bone without reducing the size of the dental arch and, as Mr. McCallin points out, spaces are created. But, if the mandible is retracted this problem of extraction does not exist; in addition, little or no proclination of upper teeth is required; once the labio-lingual relation of the incisors is correct they adjust themselves.

Mr. McCallin's paper, whilst not dogmatic, does show a desire to change what has been regarded as orthodox treatment for many years; this is a recurring feature of orthodontic practice which implies dissatisfaction with the treatment of the past, as seen a number of times in "Orthodontics: Fifty Years in Retrospect". I am not convinced that all the changes proposed are improvements and I do hope our essayist will continue to treat cases by retracting the mandible, thus bringing the lower incisors into good relation with the upper incisors which, in a large proportion of cases, will require only small, if any, compensatory labial movement to obtain a result that will more than satisfy him and his patient.

Mr. Hovell said he would like to ask Mr. McCallin one question. He had said in his paper that he never expanded the upper arch because it would relapse. He agreed entirely and absolutely with this statement. He mentioned the Continental belief that it was possible to expand the maxilla and get bony deposition at the intermaxillary suture and he would like to hear Mr. McCallin's views on this. He thought that a lot of confusion over classifications came from the belief that in all Class III dental base relationships the incisors had Class III relationships. He would not enter into the controversy over the change of dental base relationships as everybody knew his views on the subject.

Mr. Kettle asked Mr. McCallin what he considered was the most important age in the growth of the jaws when the Class III abnormality manifests itself. There seemed to be differences of opinion in the rate of the growth of the palate and of the upper jaw and many authorities believed the most rapid growth was in the first five years of life. This did not seem to be borne out by clinical observations of Class III cases and he would like to hear Mr. McCallin's opinion.

Mr. Ballard said that he did not mind raising the question of dental base relationships. He thought it was about time that somebody pointed out that "we young naughty boys" did not think up something some years ago and have been trying to prove it ever since. We still use the appliances that Mr. Chapman uses, but we have not been able to show that with these appliances we can change the dental base relationship so we are not trying to prove something, we have proved it. Brodie and others, when they began their cephalometric analysis of treated cases, did not set out to prove that they had not changed the dental base relationship; they found as a result of their investigations that they had not done so and we have come to the same conclusion. He did not consider that producing slides of models before and after treatment was worthwhile evidence, a cephalometric analysis was essential. We would like to be able to change the dental base relationship; it would make our treatments much easier.

Mr. Hartley said whilst not wishing to dispute the term "interocclusal clearance" he wanted to know why Mr. McCallin had substituted this for the original term "free-way space".

Mr. Dickson returned to the question of rapid expansion of the maxilla and said that he had been fortunate enough to see a number of these cases which had been treated and the radiographs which went with them. He said that the two halves of the maxilla were quite positively moved apart by use of the cemented appliance. The two halves of the maxilla seemed to pivot on their connexions with the surrounding bones. He did not see any cases after appliances had been removed and so he was not able to say whether they relapsed.

Mr. Readings said that he thought that the dental base that Mr. Chapman was talking about was probably not the dental base that Mr. Ballard was talking about. He understood that Mr. Ballard referred to the apical base and he thought it was necessary to make a clear definition of what was meant by dental base. He would like Mr. McCallin to clarify this point as to whether he and Mr. Chapman were referring to the same dental base.

Mr. A. C. Campbell said that he wished to ask Mr. McCallin a question concerning the treatment of the younger child with a headgear and chin cap—similar to that used by Mr. Chapman. Sometimes when this type of apparatus was used on the point of the chin and not on the lower incisors through the lower lip, he wondered if it was not possible to produce a distorting effect similar to that which the Chinese used to produce in their women's feet by binding. It was known that during the growth of the mandible the condylar angle decreases; was it not possible that sometimes using such an apparatus we might be able to accelerate or exaggerate that reduction in condylar angle? He would like Mr. McCallin's views. He said that this paper had made a point of the skeletal and soft-tissue influence and he quoted a case shown by Tulley to the E.O.S. in 1953 where there was a skeletal III dental base with a normal occlusal relationship. An interesting point was that this boy had sucked his thumb up to the age of 16. Might not the thumb have some influence in maintaining a correct incisor relationship in cases with Class III tendencies?

Mr. Walpole Day commented on the possibilities of changing the dental base relationship. He wondered if Mr. McCallin was conversant with the work of Baker who had done experimental work on animals and demonstrated, to his mind, that it was possible to produce remodelling of bone. He considered the mandible to be a long bone with a cartilage at each end. If you put stresses on it you could alter its shape if not its size. He compared it with the bowing of the legs of the horseman who spent his lifetime in the saddle. He agreed with Mr. Chapman that you could not change the basal relationship by orthodontic means using the teeth as anchorage, but by occipital traction it was reasonable to assume that we could alter growth after a period of time.

Mr. Wilson said he would like to have Mr. McCallin's views on the fact that extractions in the upper arch would tend to produce Class III malocclusions. He said that Brodie's name had been mentioned in connexion with the lack of change in apical base relationship but he felt that recent publications from Brodie's Department showed that their views were being modified, particularly in relation to the treatment of Class II malocclusions when early treatment was advised. The same could apply in Class III cases. He asked Mr. McCallin what type of pressure and what type of elastics he used to get the rapid results he had shown in some of his cases. He felt that the arch and the condyle were very sensitive to pressure and that if pressure was applied to the chin point it was most likely to affect this growth centre. He felt that the evidence supporting the contention that the apical base relationship could not change was not complete. He accepted that gross discrepancies in jaw relationship could not be corrected completely, but with the not so gross cases he was convinced from his clinical experience that changes could be produced. He thanked Mr. McCallin for a very stimulating paper.

Mr. Watkin said he had Class III cases where he reduced the size of the tongue. Had Mr. McCallin any experience in this connexion? He said that the fact that spaces remained after extraction in the lower arch was because the tongue was too big. He said that to his mind there were two types of Class III. The pseudo-Class III which was really Class I, and the hereditary type of Class III where the mandible goes on growing. In discussing the question of surgical correction of these more extreme cases, it was necessary to reduce the size of the tongue in order to prevent collapse.

Mr. J. Campbell emphasized the remarks of Mr. Walpole Day on the work of Baker. He thought that Baker had demonstrated conclusively in his animal experiments that bone growth could be retarded on the side in which the occlusion had been disturbed. This restricted the development of the basal bone of the mandible, the maxilla, and to a less extent of the cranial bones.

Miss Clinch said that the argument seemed to be that as it is not possible to prove that we are able to alter basal arch relationship it was assumed that we were not producing changes. She thought that one should weigh against that the enormous amount of clinical evidence there is from people with wide experience that they are doing this every day in practice. They may be wrong, but she did not think they should be declared to be wrong until it could be proved that they are. She thought that also applied to the expansion of the arch. There seemed to be many who thought that it was not possible to expand the maxillary arch. She thought if you were treating a case in the deciduous dentition you could expand the maxillary arch and she was doing this every day in practice. She felt it was a necessity in treating an Angle's Class II successfully.

Like Mr. Wilson, she thought that there was definitely a difference if you treated the case early. She thought this was how a lot of the argument had started—that there were two schools of thought. There was one school who waited to commence treatment until the permanent teeth had erupted and the others who treated the case almost as early as they could. She did not think you could expand the arch with permanent teeth. Two of the cases which Mr. McCallin showed which he was sure were most stable were treated at an early age.

Mr. McCallin showed one case with an everted lower lip and said that unless the patient could be trained to keep his lip in a more normal position at rest the case would relapse. Would Mr. McCallin tell her if he considers the rest position of the lip more important than the position in function?

Mr. McCallin said that he did not wish to enter into this argument, if it could be called an argument, as to whether it was possible to change dental base relationship by orthodontic means. All the evidence published to date suggests that it is not possible, and those people who claim that they can produce a change have so far not produced evidence in support of this contention. They ask us to accept clinical evidence, in most cases from a study of serial models only, and he would suggest that they should apply the same criteria with the aid of serial lateral radiographs to their cases as we apply to ours. This would be his position in the matter in replying to Mr. Chapman's observations, and Mr. Ballard had made the same point. The serial models that Mr. Chapman had shown where Class III occlusions have been improved could be explained on the principle that there had been dento-alveolar changes with little repositioning of the basal structures. Some of them undoubtedly had exhibited a degree of forward posture of the mandible in their original position, and, as pointed out in the paper, they may well have been nearly normal as far as their dental base relationship was concerned.

Serial lateral radiographs did not indicate that the wearing of a chin cap caused repositioning of the mandible relative to the maxilla, and he wondered if the reason for improved incisor relationships following its use was the result of pressure exerted through the upper part of the chin cap against the lower incisor region on the alveolar part of the bone.

In answer to Mr. Hovell, he did not say that he never expanded the upper arch. In cases of unilateral crossed bite the small amount of expansion necessary was frequently maintained. However, he was disappointed with lateral expansion of the upper arch in Class III cases in order to increase intercanine width so that upper incisors could be alined.

In replying to Mr. Kettle he said he did not know whether there was a critical age when Class III relationship was likely to manifest itself. It was frequently seen in very young children and serial studies of untreated cases had not suggested that the mandible grows forward more rapidly relative to the growth of the maxilla at any particular age. He had a feeling that mandibular prognathism would not increase relatively with growth.

Replying to Mr. Hartley he said that it was J. R. Thomson himself who had changed the terminology from free-way space to interocclusal clearance as being a more descriptive term, and Mr. McCallin had found that it was easier for students to grasp the meaning of the expression if the new terminology was used.

Replying to Mr. Readings he said that what he and his colleagues referred to as the dental base was the mandible proper or the maxilla proper in which the apices of the teeth were situated. It ceased to be the dental base at the point where the dento-alveolar structures arose. He felt that Mr. Chapman was talking about the same thing as he was.

Replying to Mr. A. C. Campbell he thought that where abnormal pressures were used over a long period it was known it was possible permanently to alter the shape of a bone, but that the type of pressures exerted by orthodontic apparatus were nowhere near sufficient to have this effect. It was possible that a chin cap through which pressure was applied to the point of a

chin of a very young patient might distort the body of the mandible to some extent. He doubted whether this distortion remained permanent, and this could not be called changing dental base relationship.

He agreed with Mr. Campbell that the thumb undoubtedly influenced incisor relationship in the case he spoke of which was shown by Tulley in 1953, but he stuck firmly to the view that the changes resulting from these pressures were related to the dento-alveolar structures rather than to the base relationship.

He said he was afraid he could not answer Mr. Walpole Day or Mr. J. Campbell as he was unfamiliar with the data that they had quoted.

In replying to Mr. Wilson he agreed that extractions from the upper arch frequently resulted in a change in the relationship of the upper and lower incisors. For example, if one were to extract teeth from the upper arch in a case with a normal occlusion one would expect the over-bite to reduce and, indeed, the upper incisors might go lingually to the lowers if muscle pressures were typical. So far as the amount of pressure and pull of the elastics that he had used were coneerned, he did not feel that the quantity of pressure was important so long as it was possible for a response to be obtained.

In reply to Mr. Watkins he said that he, too, had been involved in a reduction in tongue tissue in a case of bimaxillary protrusion and, although post-operatively the tongue was clinically much smaller, its behaviour and function were not modified. His feeling was that it was the way the tongue functioned that was important rather than its size. He said that his classification of Class III cases was in no way different from Mr. Watkins, but that they were simply expressing the same opinion in a different way.

In reply to Miss Clinch he felt that it was possible to explain the change in occlusal relationships observed clinically resulting from orthodontic treatment on the basis that the dento-alveolar structures had been repositioned upon the dental bases and that until evidence was forthcoming using the methods at our disposal with serial lateral tracings from lateral skull X-rays, or other methods as yet undescribed, it would be wise for clinieal purposes to assume that the dental base relationship could not be modified. We all hope that evidence will be forthcoming that we are wrong about this.

So far as the case with the everted lower lip was concerned, he felt that Miss Clinch had not quite understood what he said. The point he made was that unless the patient learned to position the lip against the lower labial segment and hold it there, which would involve contraction of the mentalis muscle, the lower anterior teeth would come forward. Therefore the lip was not in rest in this position but in mild function.

A CONTRIBUTION TO THE FUNCTIONAL ANATOMY OF THE MANDIBULAR JOINT

By **RUDOLPH SPRINZ,** B.D.S., F.D.S. R.C.S.

The literature on this joint is so profuse that to approach the subject with originality is nearly impossible. This is the only joint with which the dental practitioner comes in contact, and sight is often lost of the fact that there are similar joints in the human body. Histologically the sternoclavicular joint resembles the temporomandibular joint (*Figs.* 1, 2).

Fig. 1.—Temporomandibular joint. Fœtal, 110 mm. (× 21.)

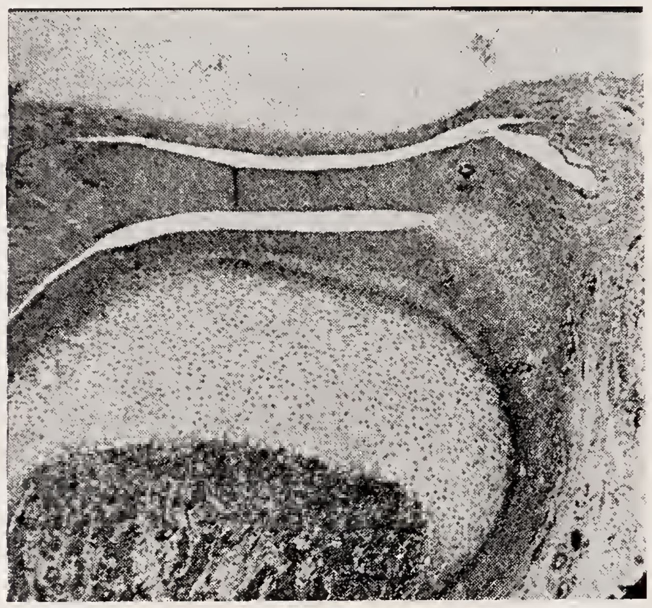

Fig. 2.—Sternoclavicular joint. Fœtal, 110 mm. (× 21.)

Histology.—The term "cartilage" is used to describe a connective tissue made up of a cellular element and a matrix containing few blood-vessels. The cells are arranged in a regular pattern, usually in columns. The matrix is a homogeneous, faintly granular structure which is interlaced by a fine network of collagen fibres. The matrix is impregnated with a chondromucoid material which gives cartilage its marked basophilic staining reaction.

This explanation is necessary in order to simplify the terminology of various structures in this joint which are often mistakenly referred to as "cartilage", as the naked-eye appearance suggests a gristle-like structure. Dense fibrous tissue can give this appearance as well as cartilage.

The mandibular joint is made up of the bony component of the condyle of the mandible inferiorly, the glenoid fossa and eminentia articularis of the temporal bone superiorly. Separating the condyle from the temporal bone is an intra-articular disk.

Fig. 3.—Head of clavicle, cartilage canal. Fœtal, 110 mm. (× 21.)

Up to the age of about 25 years the condyle of the mandible presents on its superior surface the remnants of the cartilage from which the bony condyle was formed. This cartilage is more cellular than hyaline, and contains but little intercellular matrix. This structure is described as "secondary cartilage". It is the only true cartilage tissue found in the human temporomandibular articulation, and draped

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over it on its superior aspect is a firm fibrous membrane, the articular membrane.

The secondary cartilage is one of the growth centres of the jaw. Dipping into it at intervals are deep gutters spoken of as "cartilage canals". The canals (they have been demonstrated by Haines, 1933, and Hurrel, 1934, in epiphyses of long bones) penetrate from the

Fig. 4.—Side of skull showing normal condyle position.

articular membrane through the whole depth of the cartilage to the point where ossification is taking place. They consist of a fine interlacing fibrous tissue and contain the blood-vessels supplying the cartilage (*Fig.* 3).

Sicher (1952) stresses the difference between this secondary cartilage and the epiphyses of long bones. The main difference is that the epiphysis of a long bone, as well as the head of the clavicle, presents a secondary centre of ossification. In the mandibular condyle the conversion of cartilage into bone is a continuous process and no separate centres are demonstrable. The situation, appearance, and function of the secondary cartilage are, however, noticeably similar to those of an epiphysis.

The cellularity of the cartilage may account for the abnormal behaviour of this growth centre during a disease affecting hyaline cartilage tissues—namely, achondroplasia. In this disease all cartilage structures and bones formed from cartilage are underdeveloped. Yet the mandible is quite normal and appears too large for the underdeveloped base of skull. This disharmony leads to an apparent Angle Class III in patients suffering from this disease (Stones, 1948).

The condyle, whether in the young or old, is covered by the articular membrane (also sometimes spoken of as cartilage), which is a dense fibrous tissue. The synovial space containing the lubrication fluid for the inferior compartment of the joint separates the articular membrane from the intra-articular disk, which consists of firm fibrous tissue but which is again sometimes spoken of as cartilage. A detailed study undertaken of the disk in mammalia—it is absent even in some mammals—shows that cartilage tissue and cells are rarely found here. So far only in one species, the panda (*Ailurus fulgens*), were any cartilage cells or any matrix observed.

The temporal surface of the articulation is separated from the disk by the upper compartment, again containing synovial fluid. This surface, like the condyle, is draped over by an articular fibrous membrane.

Stability.—The fact that the mandibular joint is a very stable one is accepted by most observers, though which of the following factors represents the most stabilizing is still in dispute: (*a*) the congruity of the bony surfaces; (*b*) the capsule and ligaments; (*c*) the muscular balance.

a. Congruity of Bony Components.—Although the convexity of the mandibular condyle appears to conform fairly accurately with the concavity of the glenoid fossa, actually it does not rest in the fossa, not even in the most retrusive position of the jaw (*Fig.* 4). The condyle is applied to the posterior slope of the eminentia articularis and the intra-articular disk is interposed between the head of the condyle and the upper articulating surface. Nature is capable of providing close-fitting joints, e.g., the mandibular joint in the badger (*Meles meles*). In this animal the zygomatic process almost envelops the mandibular condyle, so that disarticulation of the lower jaw is impossible without fracture of bone. On the other hand the knee-joint in man is quite stable despite no close fit between femoral condyles and tibial plateau. It

appears, therefore, that the bony components in the mandibular joint, as in the knee, may not form the essential element in the stability of the joint.

b. Capsule and Ligaments.—The capsule surrounding this joint in man is only well defined laterally, where it is re-inforced by the temporomandibular ligament. Anteriorly, posteriorly, as well as medially, it is constructed of fibrous tissue which contains many histological spaces. None the less the capsule plays some role in keeping the bony surfaces approximated, though an important function is to prevent the escape of synovial fluid.

Three ligaments are described with this joint: (1) the temporomandibular; (2) the sphenomandibular; (3) the stylomandibular ligament. Of these, the temporomandibular ligament is of some importance in preventing the dislocation posteriorly of the condyle, as this ligament, of firm fibrous structure, is attached to the tubercle of the zygoma above and to the posterior aspect of the neck of the condyle below. The sphenomandibular ligament plays a small part in stabilizing the joint, being a weak structure bridging the gap between the spine of the sphenoid and the lingula on the medial aspect of the ramus of the mandible. It is the remnant of the fibrous covering of Meckel's cartilage (the perichondrium). During the normal range of movement the distance between the lingula and the spine of the sphenoid does not alter. The movement of the jaw at the lingula is comparable to a pendulum swing whose fixed point is at the spine of the sphenoid. The stylomandibular ligament is also spoken of as a ligament associated with this joint. This ligament does not deserve the name. It is part of the deep cervical fascia which stretches from the lateral aspect of the styloid process to the angle of the jaw. Weak as these three ligaments are, it must be noted that they all exist in pairs, as two mandibular joints tie one mandible to the skull.

c. Muscle Balance.—Muscle balance is the most important factor in maintaining the functional stability of the joint. This subject has been studied by Brodie (1950) and by Last (1954). Recently electromyographic records of the muscles of the jaw have been taken by Tulley (1953), MacDougall and Andrew (1953), and others.

The concepts of Last appear to be the most accurate. He suggests that the mandible is movable on the skull in all positions of the latter and that the balance of the jaw is dependent upon the contraction of one set of muscle-fibres with the relaxation of the opposing muscles. The electromyographic slides of Tulley (1953) and of Greenfield (1955) may give an accurate idea of the components of the muscles which contract during any set movement of the jaw.

The problem of the opening of the mouth is one that has interested me for some time. Many factors, including gravity, the action of the mylohyoid and lateral pterygoid, the anterior belly of digastric, and the geniohyoid muscles have been held responsible for this movement. Last (1954) suggested that the opening of the mouth is primarily effected by the action of both parts of the digastric muscle (anterior and posterior belly) together with the lateral pterygoids. The digastric in a number of animals is a single belly muscle stretching from behind the ear to near the angle of the jaw. This muscle is known as the occipito-mandibulare and can only fulfil one function, the opening of the mouth. In most animals the occipito-mandibulare has a dual nerve-supply, from the trigeminal as well as the facial; often a slight fibrous intersection can be seen dividing that part of the muscle supplied by the former from that supplied by the latter (*Fig.* 5). The fibrous intersection is widened in primates, where the muscle has taken on a two-belly appearance (digastric). The widened intersection has become a tendon which is quite loosely bound down to the hyoid bone by means of a sling (*Fig.* 6). Contraction of the anterior belly alone would pull the relaxed posterior belly through the sling. Contraction of the posterior belly would pull the anterior belly through the sling. Contraction of both when the hyoid bone is fixed will, however, pull the chin downwards and backwards. The hyoid bone remains on the same horizontal level during opening, though it moves slightly anteriorly.

The opening mechanism is assisted by the lateral pterygoid and geniohyoid muscles, though the effect of gravity on the opening cannot be of significance.

The Intra-articular Disk.—Parsons (1900) studied this structure and wondered why the disk was missing in some animals. This fact, indeed, makes the appreciation of the reason for its existence in others very difficult. The Tasmanian devil (*Sacrophilus ursinus*) and the *Dasyurus* probably have a better functional dentition than the dog in that their premolar teeth articulate. Yet neither *Sacrophilus* nor *Dasyurus* has a disk. The badger has an upper articular surface so closely fitting around the condyle that there would appear to be little or no room for the disk. Yet this animal has a complete disk.

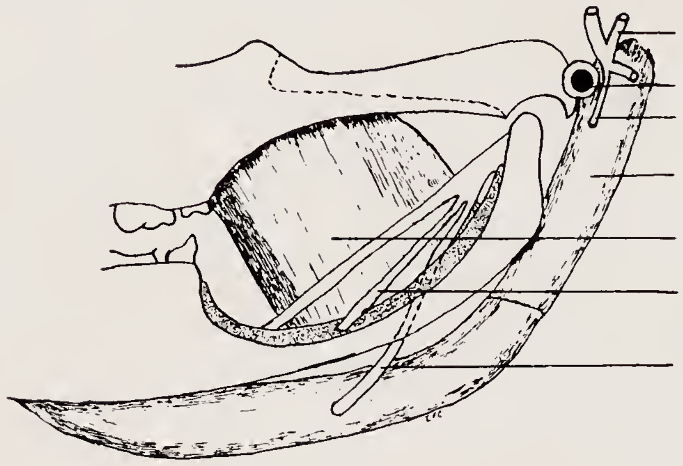

Fig. 5.—Diagram of occipito-mandibulare in the panda.

Fig. 7.—Mandibular joint of rabbit 16 weeks after partial menisceetomy. (× 15.)

The embryology of the mandibular joint has been studied by Harpman and Woollard (1938) and more recently by Symons (1952). These authors suggest that the disk is a condensed portion of the lateral pterygoid muscle, possibly its tendon. Yet in those marsupials where the disk is absent a muscle is found which is homologous with the lateral pterygoid. As Parsons has already pointed out, intra-articular disks are absent not only in some marsupials but also in some eutherian mammals, e.g., the Indian pangolin (*Manis*) and the armadillo (*Dasypus*) belonging to the order of Edentata.

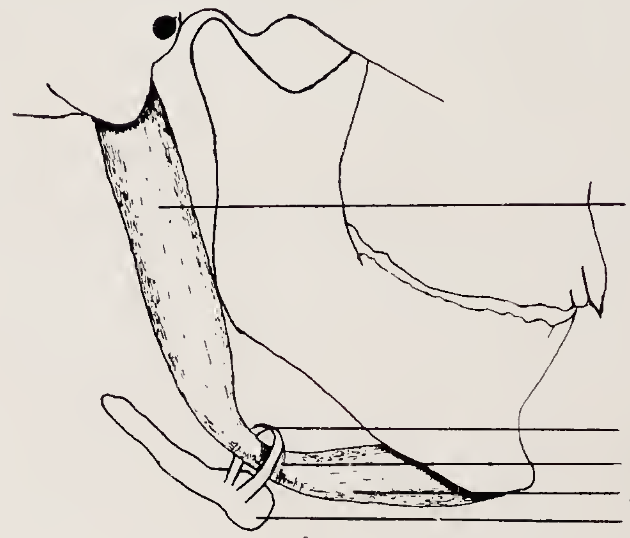

Fig. 6.—Diagram of digastric muscle.

Whatever its origin, in man the disk has an attachment in addition to that to the lateral pterygoid. Anterolaterally it is attached to the masseter muscle. This attachment was first brought to my notice by the late Leonard Rees (1954). The masseter, on contraction, would pull the disk laterally. The lateral pterygoid would pull it medially.

So far no satisfactory reason for the presence of the disk has been found. It may serve to reduce the incongruity between bony surfaces, and yet this appears unnecessary in the joint of the badger.

It may assist a joint which has to perform both hinge and gliding movements, and yet these movements occur in animals without disks, e.g., Tasmanian devil and Dasyurus.

MacConaill (1946) suggested that it acts as a lubrication flange; this may be true, though lubrication in joints lacking disks appears adequate.

It may act as a shock absorber, yet it is absent in joints subjected to stress, e.g., the ankle-joint in man. The weight-bearing parts of the knee-joint are not covered by the semilunar cartilages. It is, however, of

interest to note that in those animals where the disk is absent in the mandibular joint, the upper articular membrane is significantly thickened.

Experimental Work.—In order to gain a more accurate picture of the various components of the mandibular joint, they have been excised surgically in rabbits (Sprinz, 1954). The disk was removed in both young and adult animals and at no time was any vestige of disk re-formed (even when a part of the disk was left in situ) (*Fig.* 7). This feature is quite unlike the results of meniscectomies of the knee-joint as described by Walmesley and Bruce (1938) for the same animal. These authors showed that the semilunar cartilages had re-formed within twenty-two days after excision (but the re-formed tissue was not quite as firm as the original). From these studies it would appear that intra-articular disks may serve different functions in different joints.

The experimental work on the excision of the articular surfaces is being continued and the initial results indicate that condylar and zygomatic surfaces regenerate after bilateral excision. (Condylar regeneration in 30-day-old rats has been demonstrated by Jarabak, 1953.) The levels of the regenerated surfaces are approximately the same as the pre-operative levels, an observation which suggests that little or no pressure develops in this joint in rabbits.

A case of a woman aged 55 who died following an accident is described by Boman (1950). This patient had both mandibular disks excised nine months previously. The post-mortem examination did not reveal any signs of regeneration. This finding is contrary to the view expressed by Robinson (1946) and Hankey (1954), who suggest that the disk is capable of repair though offer no evidence for this suggestion.

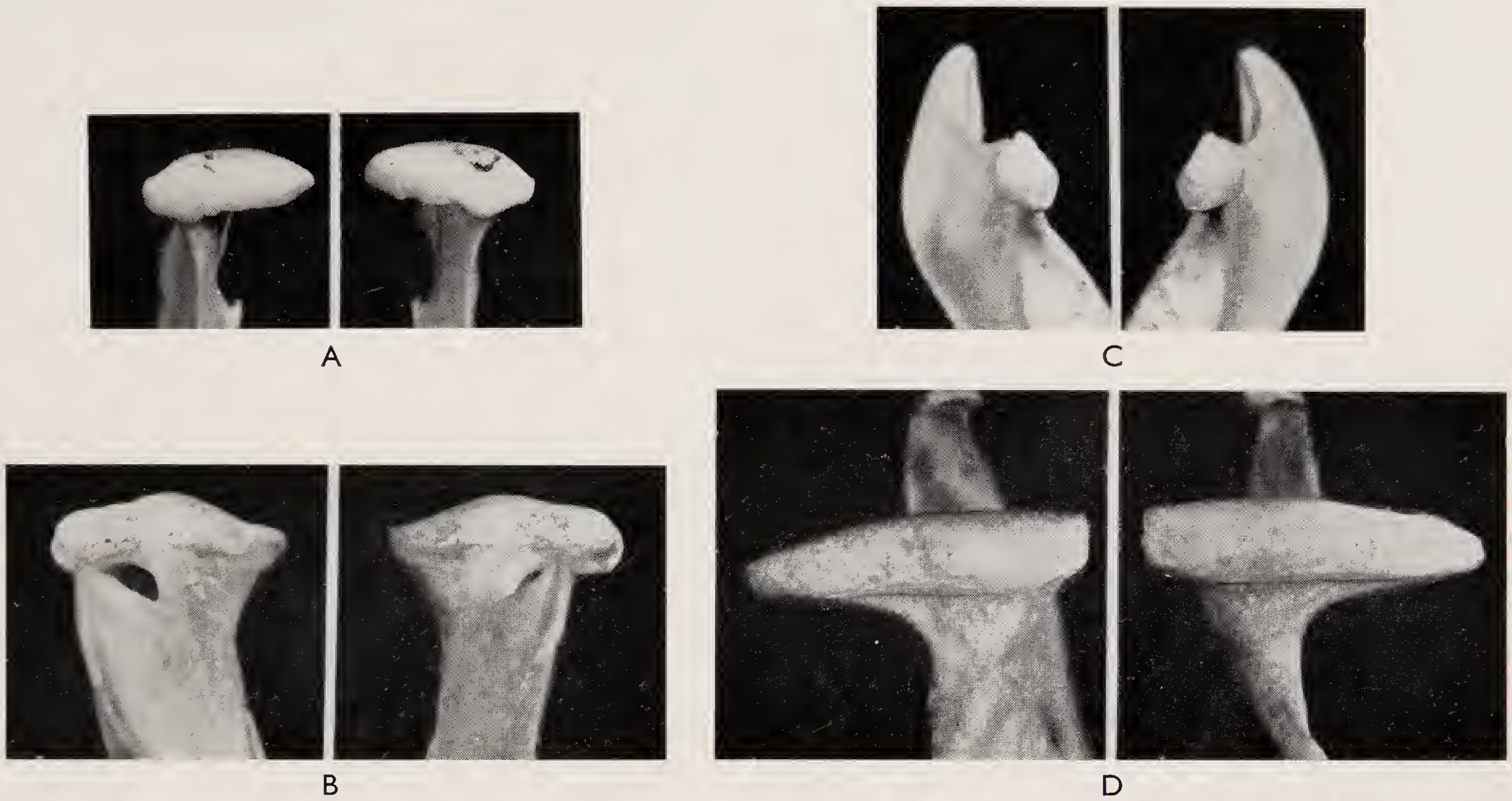

Fig. 8.—A, Human condyles; B, Condyles of dog; C, Condyles of cavy; D, Condyles of polar bear.

Statements that the condyle regenerates in man have been made to me by a number of surgeons, though as the operation of condylectomy would have followed disease of the tissue, no precise conclusion can be drawn from such cases as can be drawn from the results on experimental animals.

General Observations.—

1. *Individual Variations in Outline of Joint Components.*—Following a survey of the mandibular condyles of material available at the Charles Clifford Dental Hospital at Sheffield the following observations were made:—

A. *Human*: Mandibular condyles showed a marked asymmetry which became more marked with increasing age (*Fig.* 8 A).

B. *Comparative*: Mandibular condyles of domestic animals, such as the pig and the dog (*Fig.* 8 B), showed more asymmetry; wild animals such as the cavy (*Fig.* 8 C) and the polar bear (*Fig.* 8 D) showed hardly any asymmetry.

Fig. 9.—Radiograph of normal joint space.

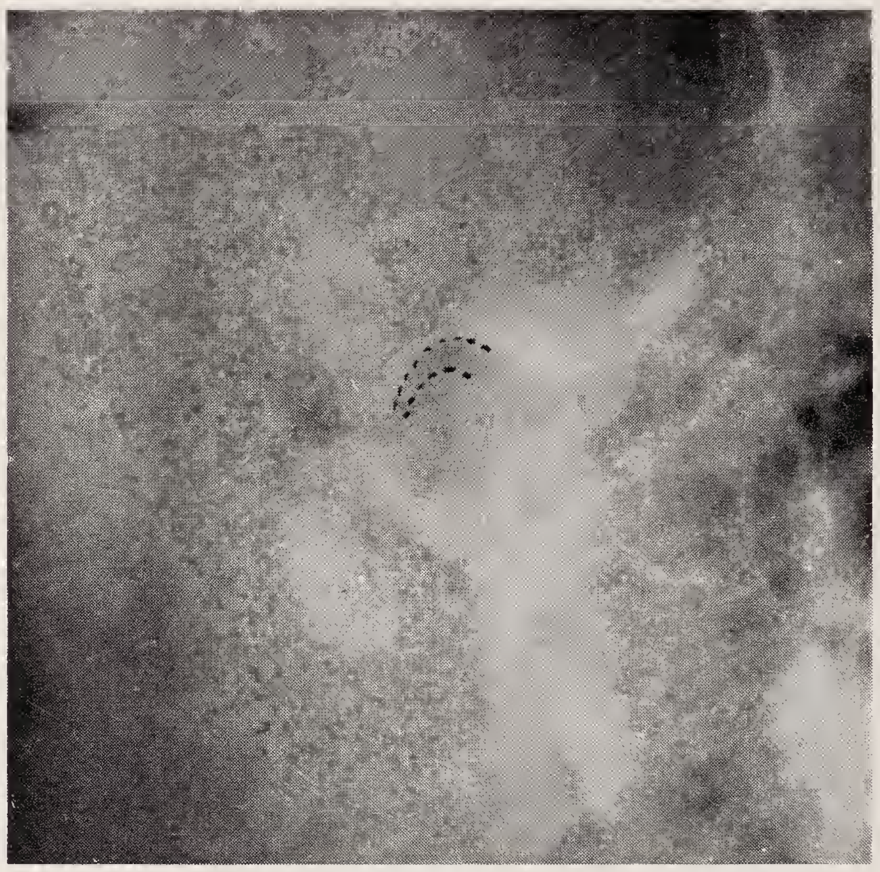

Fig. 10.—Radiograph of "reduced" joint space.

2. *Relation of Asymmetry to X-ray Appearance.*—The asymmetry mentioned above in relation to mandibular condyles may lead to misinterpretation of "joint space", a term given to the radiolucent area around the condyle as seen in a radiograph. A further complication of this problem of assessing the joint space is the fact that a reduced joint space can easily be produced by a slight tilting of the X-ray tube (*Figs.* 9, 10). Laminography would appear to be the best answer to this difficult problem of assessing the joint space.

My experimental work on the mandibular joint in rabbits suggests that even a considerable amount of surgical trauma causes few functional disturbances. Many mandibular teeth have been extracted in patients, with considerable trauma to the joint, but rarely does a joint give rise to clinical symptoms after such treatment. These observations lead me to suggest that the mandibular joint has a fairly wide safety margin and one which is not often exceeded.

SUMMARY

1. The histological appearance of the mandibular joint is described.
2. The stability of the joint is discussed, and muscular balance is considered to be the main factor responsible for stability.
3. The mechanism of opening of the mouth is described, with special reference to the role of the digastric muscle.
4. The function of the intra-articular disk is discussed, with reference to comparative anatomy and experimental surgery.
5. Asymmetry of mandibular condyles is described, and reference is made to the difficulty of assessing the correct joint space by radiography.

I wish to express my thanks to Professor Francis Davies for his valuable criticism. I would also like to thank Mr. I. F. Coombe and Mr. R. Cousins for preparing the diagrams and illustrations for this paper.

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DISCUSSION

Mr. Tulley, opening the discussion, said how pleased he was to hear a clear lecture on the basic anatomy of the temporomandibular joint. He said he thought that Mr. Sprinz would be the first to agree that, although our knowledge is improving on this joint, we are still far from fully understanding it. The electromyograph technique of studying the muscular activity has its drawbacks. He said that the histological approach on experimental animals was a very important aspect of the subject.

He thought that Mr. Sprinz's statement that the sternoclavicular joint was the same as the temporomandibular joint was open to some misinterpretation as it had no functional similarity. He entirely agreed with Mr. Sprinz about the importance of the muscle balance. He stressed the importance of studying the joint and the dentition as a functional unit.

He was not aware that it was possible for regeneration of the intra-articular disk in the knee-joint and he felt that it was not likely that such a regeneration would occur in the temporomandibular joint. He was very interested to hear that it was possible to get regeneration of the condyle in rabbits. With regard to the mechanism operating in the condylar cartilage he was not sure if he agreed with Mr. Sprinz and quoted from Sicher's work where he described appositional as well as interstitial growth of cartilage which distinguishes it from a normal epiphysial cartilage not covered by a fibrous cap.

Lastly, he entirely agreed with Mr. Sprinz that although the joint was subject to considerable abuse, cases presenting symptoms were surprisingly small.

He thanked Mr. Sprinz for a most interesting and stimulating paper.

Mr. J. Campbell mentioned all the problems of laminography and pointed out the snags in getting really precise standardized pictures of the temporomandibular joint. He said that no doubt laminography was more precise than the original oblique methods of X-raying the joint, but he pointed out, however, that the patient's head could not be completely stabilized by putting plugs in the cartilaginous portion of the external auditory meatus. He then commented on the regeneration of the condyle in rabbits. He said that he had evidence of regeneration in man. He referred to a case which he had shown to the Society in October, 1954, which was printed in the *Dental Practitioner* (February, 1955) of a woman with acute rheumatoid arthritis involving one temporomandibular joint. The condylar head had eroded into a stump with a sharp spike. Plans were made to resect the remains of the condyle, but her condition improved and muscle spasms disappeared and serial laminographs showed a regeneration of the condyle or at least a rounding off or formation of a better articular surface. Mr. Campbell thanked Mr. Sprinz for opening up a channel of animal experiments on the joint, which he thought were most valuable.

Mr. J. Beresford said that in the human joint, if you suspect that there is something wrong with the disk you can hear a definite click and can feel the roughness of the movement by palpation. Could Mr. Sprinz say whether he had observed any clicking or roughness in rabbits where he had removed the disk?

Mr. G. Taylor questioned the musculature in the mechanism of mouth opening. He reported a patient who had no digastric muscle as it had been destroyed by radium treatment and who was quite able to open his mouth freely. He thought that more conclusive evidence of the role of the digastric muscle in mouth opening should be produced by electromyograph recordings.

Mr. Sprinz, in reply to the discussion, said that he was well aware of the gaps in our knowledge concerning the temporomandibular joint which was one of the reasons why he was doing his present research and he thought that in twenty years' time he might be in a better position to explain some of the present unknown factors. He said that there was nothing he could add to Mr. Campbell's exposition on the X-ray side of the problem. He said that it was important to bear in mind the differences in the shape of the joint on each side. He agreed with Mr. Tulley that the dentition must be studied in conjunction with the joint. He said that he was grateful to Mr. Tulley for making the point concerning the difference between the mandibular growth centre and the epiphysial cartilage.

In connexion with the sternoclavicular joint, he had only likened it to the temporomandibular joint in its histological structure and not from the functional viewpoint. In connexion with the regeneration of the disk, he had been very careful to keep off the clinical aspect. He quoted from an article by Boman in which postmortem investigations failed to show any regeneration of the disk following its removal nine months previously. With regard to the regeneration of the cartilage in the knee-joint, which he had discussed with Mr. Tulley, there were several authorities who had produced evidence to show that this did occur. He would add, however, that by regeneration (both in man and animals) he did not mean the structure returned to its original form quickly.

In reply to Mr. Beresford, he had never heard a clicking in the temporomandibular joint of rabbits.

In reply to Mr. Taylor he said that he did not consider that one should quote gross pathology to support theories on normal function. It was well known that muscles can undertake trick movements, and in such a case as Mr. Taylor had quoted other muscles would take over the role of those which had been lost.

PRELIMINARY INVESTIGATION OF MANDIBULAR GUIDANCE IN POSTURAL CLASS III CASES

By **J. HOPPER,** L.D.S.

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It has been customary to divide cases of prenormal incisor relation into two main groups: (1) Those exhibiting a true mandibular prenormality; and (2) Those cases exhibiting a false or postural prenormal mandibular relationship.

In a text by Haupl, Grossman, and Clarkson (1952), A. M. Schwarz is quoted as dividing cases of prenormal occlusion into two groups—those in which "forced bite" occurs owing to inclination of anterior teeth, and those with abnormal growth in length of the mandible, without forced bite or inclination of the teeth.

It seems to be generally accepted that in the postural Class III the mandible is displaced anteriorly on closure and all that is required of treatment is a repositioning of the mandible in a distal direction.

Patients observed clinically both before and after treatment were noted to differ but little in their buccal occlusal relationships so the question arose—was in fact the mandible repositioned distally as was current belief?

A review of the literature on the subject revealed no attempt until comparatively recently to correlate the apparent anterior mandibular positioning with the position of the condyles in the glenoid fossæ. Statements that the mandible was "forced forward" in closure or guided anteriorly, were frequently found (Erdreich, 1945; Haupl and others, 1952; Hemley, 1939, 1953; Lundstrom, 1954).

Erdreich (1945), for example, reporting details of this type of case, stated that "these cases are characterized by a linguoversion of the maxillary incisors in relation to the mandibular incisors and by a forward positioning of the mandible. None could be classified as typical Class III malocclusions which exhibit an inherent overgrowth of the mandible, but are more correctly classified under what Fisk calls the atypical type, which includes in some cases diminished maxillary growth and in others a protrusion of the mandible for convenience."

More recently Thorne (1951) examined 26 cases of prenormal occlusion and found that 10 exhibited a pure hinge movement of the condyle between rest and occlusion, 15 showed a distal displacement, and in only 1 case did there appear to be any anterior displacement and that of the order of $\frac{1}{2}$ mm. While development was taking place on methods of more accurately assessing condylar displacement, patients were selected and examined by routine clinical methods in order to find out if any anterior displacement was clearly evident.

CLINICAL MATERIAL AND METHODS

All patients attending the clinic who exhibited a prenormal incisor relationship were carefully examined and any who were obviously of prenormal mandibular base relationship were rejected for the purposes of this study.

By their very nature cases suspected of possessing anterior displacement will only exhibit a minor degree of mandibular prenormality when seen in the position of occlusion. However, it is just this matter of deciding minor degrees of disharmony in the basal relationship which is so difficult since the variation from normal to prenormal is a gradual and continuous transition.

Mandibular position reflects to the full the concept of "continuous variability" permeating the whole of biological phenomena and

Given at the Sheffield meeting held on May 7, 1955.

hence it is virtually impossible to lay down a precise point at which the mandible should be considered prenormal for any individual case.

For these reasons, in the present investigation, the cases were selected by clinical observation, rather than by resorting to some mathematical computation based on cephalometric analysis.

The majority of these cases could achieve edge-to-edge incisor relationship, a characteristic sometimes quoted as distinguishing the postural Class III type of case.

The temporomandibular joint radiographs were largely taken according to the method described by Grewcock (1953) and were obtained in the positions of rest and occlusion.

For the purposes of projecting, these films were traced and the tracings only shown on the screen, as the films themselves do not project very clearly. Original films could be examined on the viewers.

Cephalometric radiographs were taken at the rest position and in occlusion to determine the individual craniofacial skeletal pattern.

FINDINGS

In interpreting the results, the limitations of radiography, particularly oblique radiography, must be borne in mind.

It is quite possible that small movements of the condyle do occur between rest and occlusion, so producing an alteration in the relative position of the condyle to the glenoid fossa that is too small to be detected in the radiograph.

As finite points from which to measure do not exist, one must guard against being too dogmatic in one's statements.

On examining the temporomandibular joint radiographs, bearing the preceding statements in mind, it can be seen that no displacement of the condyle anteriorly occurs between the positions of rest and occlusion. In the majority of cases the position of the condyle at rest and in occlusion coincided. (*Figs.* 1, 2.) In one or two cases there was slight distal displacement (*Figs.* 3, 4).

It is interesting to note that if the upper incisors are moved labially to even a small extent, i.e., before they have achieved either an edge-to-edge contact or correct relationship with the lower incisors, then the condyle is in fact displaced anteriorly (*Figs.* 5, 6).

If the appliance was removed at this stage, the incisors would no doubt relapse until equilibrium was once more established in the original incisor relation and no displacement of the condyle would then occur.

Fig. 1.

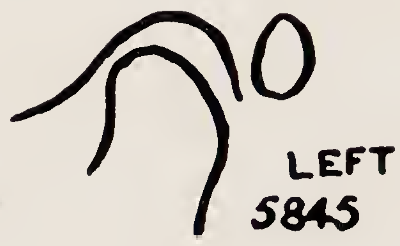

Fig. 2.

Fig. 1.—Position of condyle at rest and in occlusion coincides.

Fig. 2.—Position of condyle at rest and in occlusion coincides.

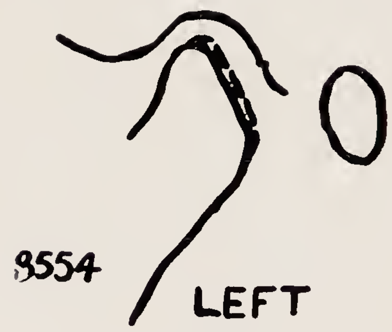

Fig. 3.

Fig. 4.

Fig. 3.—Slight distal displacement of condyle. Rest position, continuous line; occlusal position, broken line.

Fig. 4.—Slight distal displacement of condyle. Rest position, continuous line; occlusal position, broken line.

Fig. 5.

Fig. 6.

Fig. 5.—Position of condyle at rest position.

Fig. 6.—Position of condyle after slight labia movement of upper incisors.

Therefore considering this latter factor and on examining the cephalometric tracing of a case, it is possible that on eruption of the incisors (*Fig.* 7) the upper incisors are guided, or erupt in the path of least resistance with a palatal inclination, and the lower incisors

erupt with a labial inclination. Other hypotheses can account for the negative incisor relation which I will not mention here.

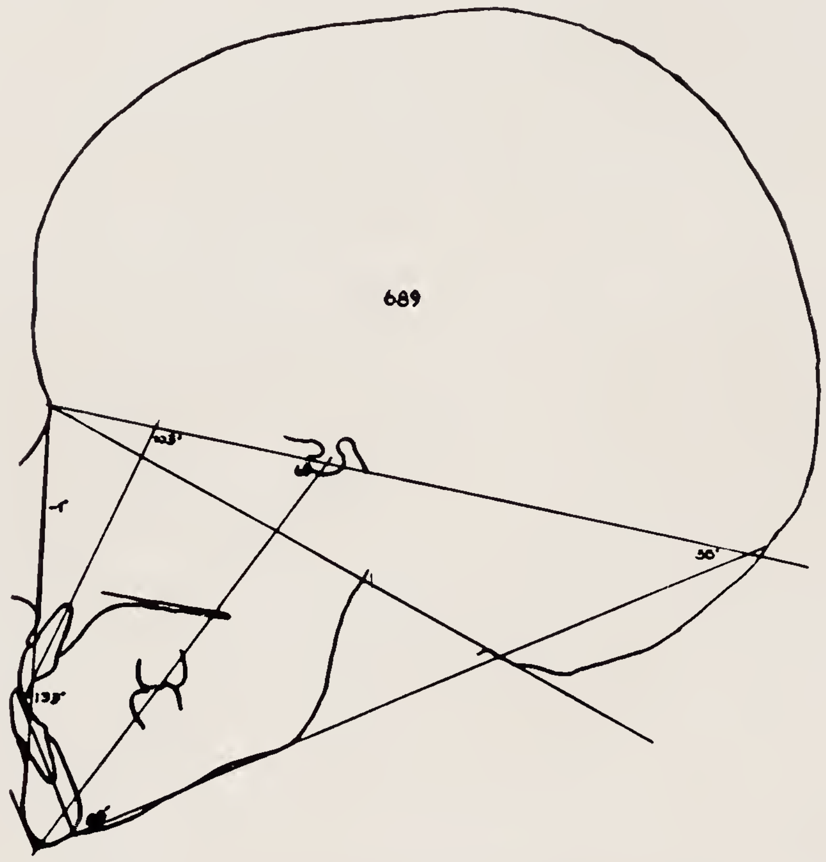

Fig. 7.—Lateral skull radiograph tracing to show teeth together.

relationship remaining relatively static. (A small degree of condylar displacement may occur until the occlusion has settled down.)

Morphologically many of these cases are described as Angle Class I. Thus, Hemley (1953) states "at times it may be impossible for the patient to establish a functional occlusion without sliding the mandible forward", and he continues, "if the maxillary incisors have a marked lingual axial inclination, the patient may not be able to bring the posterior teeth into occlusion without sliding the condyles forward—these should be considered as Angle Class I cases."

On cephalometric analysis it appears that these cases are in reality mild cases of mandibular prenormality (*Fig.* 9), though, as has been mentioned previously, it is often difficult to state definitely which side of the dividing line one would place them, whether normal or prenormal. To quote from a paper by Johnson (1950): "Both Brodie and Wylie have called

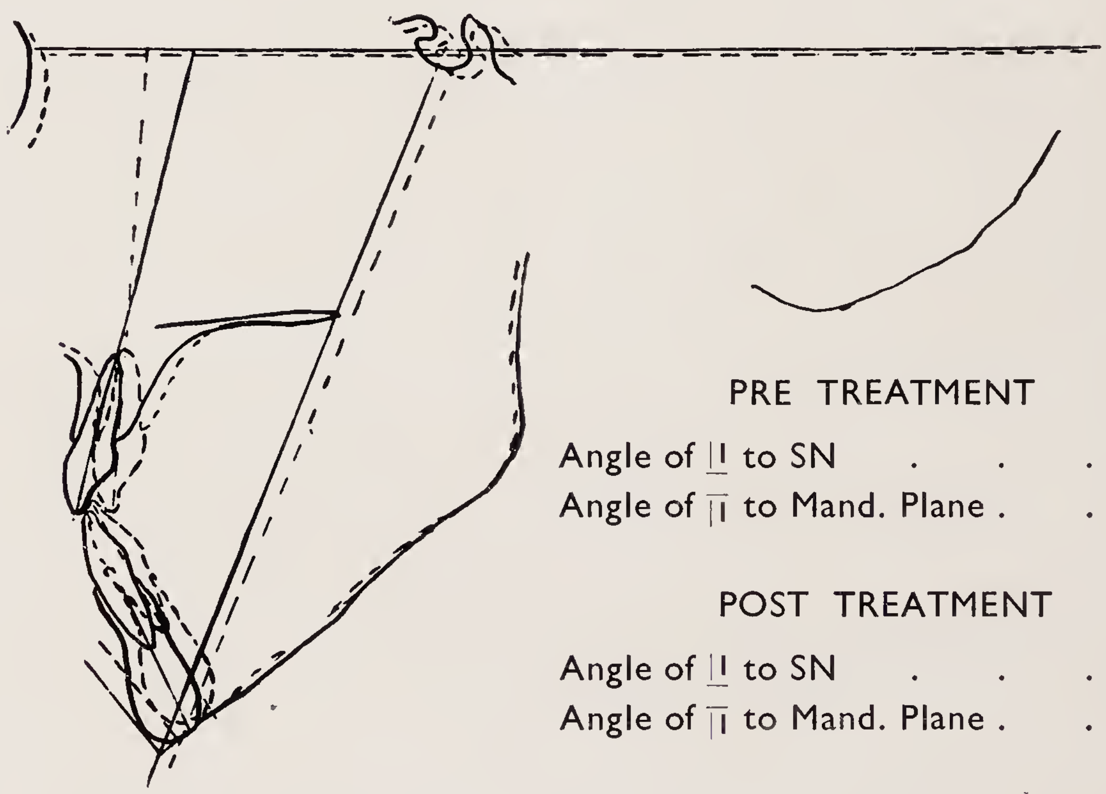

Fig. 8.—Tracings compared before and after treatment.

At this stage one might well ask what in fact does occur during treatment if one does not re-position the mandible distally?

On examination of the cephalometric tracing of a treated case (*Fig.* 8) it is apparent that the upper incisors are inclined labially and the lower incisors lingually until a normal relationship is attained, the condyle—glenoid

for re-orientation of orthodontic thinking concerning the basis of deviations from the so-called 'normal' facial pattern and have maintained that these deviations should not necessarily be considered as defects of growth, or as undesirable postnatal alterations in craniofacial morphology, or even as abnormalities. Instead it has been suggested by

them that many of these facial patterns which orthodontists find undesirable are in reality only the random combination of separate facial parts, each of which is within the normal range of variation in confirmation

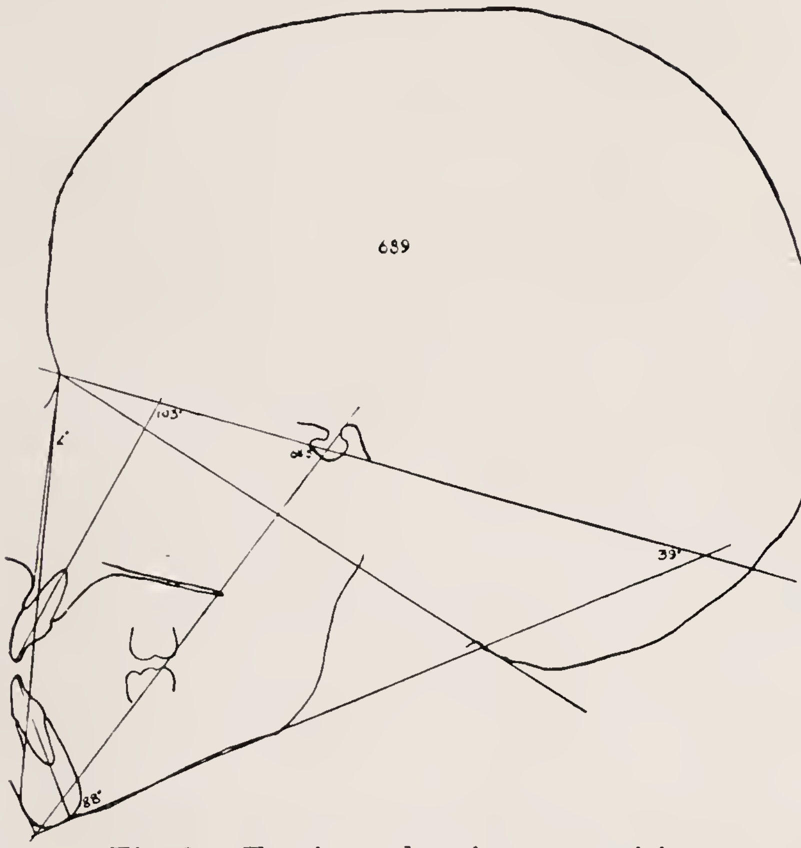

Fig. 9.—Tracing taken in rest position.

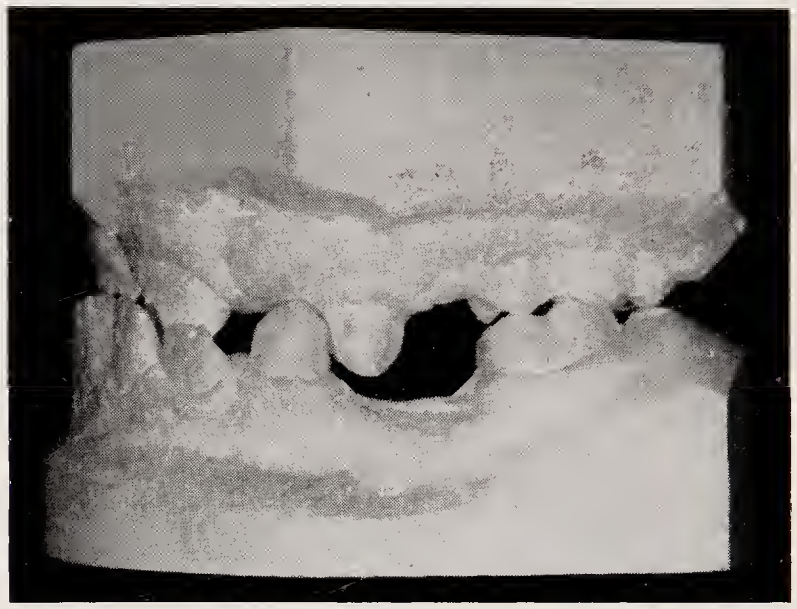

Fig. 10.—Model of the type of case.

Fig. 11.—Profile in occlusion.

Fig. 12.—Profile in rest position.

and size, but which, *in toto*, combine to produce an undesirable facial configuration."

A further morphological feature of these cases was that a large number of them exhibited an increased freeway space. This could be due to faulty muscle patterning or maybe due to overloading of the buccal segments, as many patients possessed a minimum of posterior teeth (*Fig.* 10). Mr. Ballard will have something to say regarding the former in his paper, particularly in its connexion with anterior positioning of the mandible.

Clinically, overclosure (*Figs.* 11, 12) can give the impression that the mandible is displaced anteriorly because during the over-rotation of the condyle the chin point swings further anteriorly as well as upwards towards the base of the nose.

Summing up, anterior guidance has not been demonstrated in this series of cases, though it would be rash to state categorically that it did not exist at all.

The methods used in this preliminary survey do not achieve the accuracy one would wish, particularly with regard to oblique radiography and, further, many more cases will have to be investigated than the present series of about 30.

Acknowledgements.—The writer is indebted to Mr. J. W. Softley and colleagues, of the Orthodontic Department of the Liverpool Dental Hospital, for much helpful advice and criticism; and also Mr. S. Baillie for his care in the preparation of the photographs.

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DISCUSSION

Mr. Pringle thanked Mr. Hopper for his paper and said that he thought the preliminary investigation was a good one. What had always puzzled him was that, for example at Guy's in 1937, there were 200 children with what was called postural prenormal occlusions. This was a small number compared to the very large number of children in London who had had deciduous molar extractions that had not gone into a forward posture. What was the factor that determined whether or not a forward posture came about? There must be skeletal III tendencies in these cases. He thought that in one of the photographs Mr. Hopper had shown, the mandible had come forward as well as overclosed. He added a note of caution over the interpretation of X-rays of the temporomandibular joint.

Mr. Hovell said that Mr. Hopper had shown by scientific observations that there was not a forward movement of the mandible in postural Class III cases which is what clinicians had thought happened. He asked whether Mr. Hopper had undertaken any electromyographic investigations on these cases and also whether the freeway space returned to normal after treatment.

Professor Hallett sounded a further note of warning about the interpretation of temporomandibular X-rays before and after treatment. He said that we still had to develop a technique for doing this and he had found by X-raying his own joint how the slightest movement could produce errors and that with our present methods only gross changes in condyle-fossa relationship could be taken into account. He pointed out that the laminagraph gave a fairly accurate method of making a "cut", but this was still open to some error.

Mr. Tulley asked Mr. Hopper the time interval between some of his X-rays taken before and after treatment. He had noticed himself that in comparing treated cases after one year, the downward and forward growth of the maxilla appeared to exceed that of the mandible following the pushing of upper incisors over the bite. This raised the problem in assessing what the treatment had actually achieved because of the unknown growth potential during the period of treatment.

Mr. Pringle said that obviously most of the speakers were dissatisfied with the techniques of joint radiography when making measurements of joint movement. He said that it was difficult to be sure that it was really scientific. He asked Mr. Hopper to reply.

Mr. Hopper in reply to Mr. Pringle, said he agreed that the skeletal morphology was the triggering factor in deciding negative incisor relationship. There were other possibilities, which no doubt Mr. Ballard would mention, the incisors erupting, edge-to-edge contact and, to avoid that contact, the forward positioning of the mandible, which is perpetuated and aided, he thought, by the lack of posterior teeth, the patient had to bite on the incisors and the only way they could go was anteriorally.

With regard to Mr. Pringle's question about the photograph, upward rotation of the lower incisors and chin point in overclosure always carried this point into a more anterior position relative to the normal, but was not an indication of bodily forward movement of the mandible.

In answer to Mr. Hovell he did not use an electromyograph to analyse his cases, but he hoped to do so in the future. He would expect to see electromyographic changes in these cases.

In reply to Mr. Tulley he said that the time between the X-rays was about 3 sec. They were taken with the patient or tube position at rest and in occlusion. He agreed that in making any assessments of before and after treatment, interpretation was very difficult owing to the inability to standardize X-ray technique. The changes were too small often to be accurately interpreted.

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A CONSIDERATION OF THE PHYSIOLOGICAL BACKGROUND OF MANDIBULAR POSTURE AND MOVEMENT

By **C. F. BALLARD**, F.D.S. R.C.S., M.R.C.S., L.R.C.P., D. Orth. R.C.S.
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In the past many erroneous theories and deductions have been built up around the study of orthodontics; theories formulated with a lack of understanding of the evolutionary relationship between form and function in particular. This paper will endeavour to stress the evolutionary background of function, and the significance of this in explaining clinical findings.

Rogers (1950) myofunctional therapy could not be generally accepted because it did not work for reasons which will be apparent later. The Angle philosophy, although accepted by a large number of people, was based on the concept that the function of normal occlusion will stimulate the skeletal structures to grow, and the theory of functional therapy evolved round the Andresen or Monobloc appliance is based on the concept that function can be changed and that there will be a resultant change in the form of the jaws, the mandible in particular.

Most of these theories have been disproved by subsequent clinical analysis of a large number of cases, but many still remain to cloud the issue and hinder the transition of orthodontics from an art to a science.

In 1947 Gwynne-Evans and Ballard, realizing that the exercising of muscle patterns as in the myofunctional methods was not a physiological approach to the problem, conceived the idea of "re-educating" tongue and lip behaviour reflexly by the Andresen appliance. This again has failed for reasons now obvious.

The scientific assessment by Brash (1929) and the results of such investigations as that by Brodie, Downs, Goldstein, and Myer (1938) stimulated some of us to a more critical analysis of the whole aetiological background of malocclusion and its relation to treatment.

Brash said: "It appears that at the back of all this discussion about the lack of use of the jaws is the erroneous assumption that growth and size of bones must be in some direct ratio to the magnitude of the forces applied to them and the frequency of that application; whereas it is more than probable that there is a very wide range of activity within which growth will proceed in a perfectly normal manner, and that it requires an altogether exceptional degree of lack of use, amounting almost to cessation of use, to affect in any degree the growth of the bones concerned. No amount of exercise, on the other hand, can possibly induce any part of the skeleton to grow beyond the limits to which it is congenitally predetermined."

Investigations by Brodie and others (1938) showed that orthodontic treatment did not change the dental base relationship, but that nearly all the changes were in alveolar bone.

An analysis of treated cases soon confirmed that even if appliances other than those in Brodie's investigations were used, and these included the so-called functional appliances, the conclusions were correct. This finding opened up a whole field of investigation into the question of the aetiology of malocclusion and the factors which permitted satisfactory results to be obtained in some cases but which in others caused relapse.

Careful unprejudiced clinical observation and recording of several thousand cases led to three important conclusions.—

1. That the dental arches, whether normal or abnormal, were in a position that was in balance in soft-tissue morphology and behaviour.

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2. The stability of the end-result depended on the dental arches also being in balance in soft-tissue morphology and behaviour.

3. Soft-tissue morphology and behaviour was not nearly so amenable to change and re-education as had generally been believed. As far as this concerns the linguo-facial balance of the arches, this has been discussed and illustrated elsewhere. (Rix, 1946, 1953; Ballard, 1948, 1951 a, b, 1953, 1955; Gwynne-Evans and Ballard, 1947; Tulley, 1954.)

It might be as well to point out to would-be critics that the conclusions have been arrived at by inductive reasoning after an unprejudiced clinical analysis of many thousands of cases. Theories were abandoned because they were not in accord with clinical findings. It would seem that now is the time to attempt to formulate a new scientific approach based both on experimental biology, conclusions drawn by biologists studying animal behaviour, and on our own clinical observation.

The conclusions set out above led to an investigation into the whole biological background of behaviour in order to support, if possible, the new conclusions and show why the old ones were wrong. It is the purpose of this paper to describe, very briefly, the scope of the experimental work on investigations into the biology of behaviour and then, relating conclusions drawn to clinical observation, to suggest a more biological approach to orofacial soft-tissue behaviour and in particular to the posture and movement of the mandible.

For many years it has been vaguely appreciated that function must play an important part in orthodontics, but its true significance has been overlooked. Gesell (1942, 1945, 1952, 1954) gave orthodontists a clue to the problem which we have been slow to accept. He said: "and just as bone and teeth have characteristic forms, so do patterns of behaviour.

"What is meant by a behaviour pattern? Simply a defined, formed response of the neuromotor system to a specific situation.

"Whether we are concerned with bones or behaviour, the fundamental determiners of form are intrinsic; they are endogenous rather than exogenous. So-called environment does not generate the progressions of development. Environmental factors support, inflect, and specify, but they do not engender, the basic forms and sequence of ontogenesis.

"This principle of maturation certainly applies to the physical morphology of the mouth and to the movements of the mouth."

Behaviour biologically is the total response that an organism makes to any situation with which it is faced. This includes at one extreme the simple reflex activity which physiologists have investigated and, at the other extreme, the highly complex behaviour which psychologists have attempted to analyse. In between these two extremes, however, there are many levels of integration which are important from our point of view because orofacial behaviour is organized at a higher level than the simple reflex, but, except possibly in the case of sucking "habits", not at the level that has concerned psychologists.

Weiss (1941) outlined in 1925 the hierarchical concept of the organization of behaviour by which it is envisaged that there is, in the nervous system, ascending complexities of organization. For example, the stable patterns of motor activity for moving joints is at a comparatively low level. Then at a slightly higher level these are co-ordinated to produce walking and swimming, etc., and these levels of activity are organized at a still higher level to produce the complex behaviour such as feeding, hunting, mating, etc.

Darwin realized the importance of behaviour in its wider sense in natural selection, but the work of Tinbergen (1950, 1951), Lorenz (1950), and others has enabled them to break down behaviour into:—

1. Co-ordinating patterns of motor activity endogenous within the central nervous system.

2. The environmental stimuli which reflexly call forth specific complex patterns of activity which are composed from the endogenous co-ordinating patterns.

In the field of experimental biology, Weiss (1941) demonstrated the principle of myotypic (muscle specific) response which discounts the idea of trial and error learning or that of stereotyped nervous development, producing patterns of motor activity in the individual. He transplanted limb buds, limbs, and single

muscle of amphibia to the opposite side of the body. After the transplanted muscle had received nervous connexions from the segments supplying the limb on the opposite side of the body from their side of origin, it was found to contract synchronously with the muscle of the same name in that limb. In the case of whole limb or limb bud transplants, the muscles when the limb bud had developed, or the limb had received nervous connexions, were found to contract synchronously with the muscles of the normal limb. They performed the same pattern of activity as the normal limb, but, because they were reversed, the activity was opposed to the requirements of the organism.

In the case of a reversal of both fore limbs, the activity of these fore limbs was again a complete reversal of the requirements of the individual.

His experimental work (Weiss, 1950) did not overlook the sensory side, and, in discussing the behaviour of transplanted limbs and muscles, he said: "This very fact that the transplanted muscles contracted in accordance with their names, rather than in accordance with their positions, proves that co-ordination patterns are determined centrally and that the central patterns, though normally reinforced by proprioceptive reflexes, take precedence over the latter under conflicting circumstances. The well-established fact that completely de-afferented limbs continue to function without essential impairment of their co-ordination likewise proves that intramember co-ordination cannot possibly be the result of chain reflexes. This in no way detracts from the importance of proprioceptive reflexes as subsidiary reinforcement mechanisms."

On the embryological side, a pioneer in the study of the development of behaviour was Coghill (1914–1936) with the Amblystoma; and Gesell (1942, 1945, 1954) has studied the development of motor activity in the human fœtus and carried these on to post-natal maturation. The general conclusion that can be drawn from this work is that every species of organism has a genetically determined sequence of development both of morphology and motor activity. Gesell (1952) said: "The so-called environment (extrinsic factors) cannot generate the progressions of ontogenesis—the momentous movement from zygote to embryo to fœtus to infant, and the dramatic advance from limb bud to hand to reflex grasp to voluntary prehension, manipulation, and construction.

"These progressions are primarily governed by genes functioning as chemical agents obedient to cues. Maturational mechanisms underlie the marvellous sequence of ontogenesis. Maturation is the net sum of the gene effects operating in a self-limited life cycle."

A review of this subject was made by Davenport Hooker in 1952.

It would appear, then, that patterns of motor activity develop endogenously and that what we have thought to be learning is in fact the result of the processes of maturation of the central nervous system.

To test this theory, Carmichael (1926, 1927) investigated the incipient swimming movements of tadpoles while still in the egg capsule. He kept a group of them under continuous chloretone anæsthesia. When a control group had reached a stage of activity which could be well assessed, those under the chloretone anæsthesia were placed in fresh water and were found to be in exactly the same stage of maturation as those who had apparently been learning the swimming activities.

Similar observations have been made by other workers on other animals.

With regard to behaviour of a more highly complex nature, it is interesting to note that Hess in 1944, by stimulating the diencephalon of intact cats with electrodes, succeeded in producing complex patterns of behaviour such as fighting, hunting, and sleeping.

Finally, in this very brief review of the biological background to orofacial behaviour, it must be noted that just as morphology has evolved through natural selection, so has behaviour. Both morphology and behaviour are adapted for the survival of the individual in an expected environment and each individual has a limited power to adapt to a new environment.

In Weiss's experiments the amphibia with the transposed limbs showed no power to adapt

their neuromotor system to the new situation, even after as long a period as a year. In mammals, also, there is little evidence of adaptation.

Sperry (1940, 1945) performed tendon and nerve cross-experiments in rats and found that they cannot overcome the resulting disorder. Sperry also reported that with similar experiments on monkeys there was only "a possibility of a very faint trace of adaptation" to the disorganization of function. In man, nerve and tendon crosses are performed to help the individual to overcome a disability, but, here again, the power to adapt is dependent on long training and almost certainly much conscious effort.

The new patterns of activity produced do not replace the endogenous ones but only control them from a higher level. In moments of stress, sleep, etc., endogenous patterns reassert themselves, even after many years.

The author suggests that in applying the present-day concepts on behaviour to that of orofacial behaviour, the following hypotheses can be stated:—

1. The mandible has a postural relationship to the maxilla which is endogenously determined, mature at birth, and probably remains stable throughout life.

2. There is a repertoire of patterns of activity of the muscles of mastication, likewise endogenous, used for mastication, speech, etc.

3. These hypotheses apply to the muscles of the tongue and muscles of facial expression.

4. The position of the dento-alveolar structures developing from the dental bases and their occlusal level is determined by the posture and activity of the orofacial and masticatory muscles.

It is also possible to suggest that any adaptation of behaviour to occlusal variations (environmental factors) or changes of patterns of activity, theoretically required for correction of a malocclusion, must be by one of the following mechanisms:—

1. By conscious control and prolonged practice.

2. By a reflex activity, the physiological mechanism for this being already present in the individual as a result of evolution.

If these hypotheses are correct, it is important for the orthodontist, and in fact the prosthetist or periodontist, to know whether there is any reflex adaptive ability in orofacial activity and, if there is, the extent to which it can be used.

As has been previously mentioned, clinical observations on the behaviour of tongue and muscles of expression in relation to the linguofacial balance of the dental arches and their significance in prognosis and treatment planning have been reported elsewhere by Ballard, Rix, and Tulley.

It is now proposed to relate these hypotheses to clinical observation on the posture and movements of the mandible, firstly in relation to normal development. As has been previously pointed out (Ballard, 1953) the newborn infant, clinically, has a definite posture of the mandible, tongue, palate, and facial soft tissue. This level of maturation has to be reached by birth for the survival of the individual. It maintains a closed oral cavity and clear post-nasal airway. The newborn infant also has the power to respond to at least two environmental situations in specific ways.

At birth, respiration commences reflexly and when food stimulates the dorsum of the tongue, the feeding pattern of activity also commences reflexly. Further than this, Gesell has suggested that the "tonic neck reflex" which develops in utero is important in:—

1. Orientating the fœtus to the birth canal;

2. Posturing the infant at the breast.

Into this already comparatively mature morphology of behaviour, the dento-alveolar structures develop from the dental bases into occlusion.

The dento-alveolar structures grow vertically into a genetically predetermined intermaxillary space until their inherent power of growth is balanced physiologically by masticatory and other mandibular activities. The forces involved must be very light because two teeth in contact are sufficient to maintain a normal interocclusal clearance. A reflex mechanism is almost certainly involved.

The result of the work of Thompson and Brodie (1942) and Thompson (1946, 1949)

on the physiological rest position and the interocclusal clearance, lends support to the view that the postural position of the mandible is endogenous in the individual and that the occlusal level is physiologically established.

The term "physiological rest position" has led to some confusion. Electromyographically there is a minimum of electrical activity in the muscles which maintain the posture when the individual is sitting upright, has a natural position of the head, and is looking straight forward. However, this posture is not maintained as the result of the reciprocal activity of groups of muscles at a physiological resting tonus. Nor is it simply the result of activity of anti-gravity muscles with resting tonus of depressors. If the individual is inverted, the mandible still maintains this postural relationship to maxilla, but quite obviously the pattern of muscle activity has had to be changed. The postural position is a property of the central nervous system. In the majority of individuals, this postural position of the mandible is maintained even during sleep. The term "physiological rest position" is misleading, therefore, and a more correct definition would be the "endogenous postural position".

Many workers in attempting to confirm Thompson's finding of the constant postural position of the mandible, discovered varying degrees of inconstancy. In the author's view this is due to the nature of the experimental methods. As soon as an individual's posture is disturbed, either by having his head clamped in a cephalostat or as the result of a conscious knowledge of what the observer wants, then the endogenous postural pattern of activity may not be produced. Only by careful clinical observation can the true postural position be found in each individual and when found it can then be reproduced for purposes of recording, radiographically or by other means.

Thompson also investigated the path of closure from "physiological rest position" (endogenous postural position) to occlusion. He found that the normal path of closure was a smooth movement into occlusion through a distance which is the interocclusal clearance of about $2\frac{1}{2}$ mm. The direction as represented by the lower incisor was upwards and slightly forward. At occlusion there was a uniform contact of the whole dentition. This activity has been and is being investigated electromyographically, and the general conclusions seem to be that there is a uniform activity of bilateral pairs of muscles although the pattern of activity has individual characteristics. Thompson also found certain types of variations in this path of closure. The abnormalities in the path of closure which he described, and with which we are concerned at the moment, are those in which the mandible, moving through the normal path of closure, makes an occlusal contact which is abnormal in that the inclined planes appear to result in a sliding action with the path of closure thereafter deviating along the inclined planes either distally, laterally, or mesially.

Since Thompson's original work was published, these abnormal paths of closure have been further investigated. An attempt was made last year by Ballard and Grewcock (1954), as the result of this fuller analysis, to explain the physiological background. The important clinical observations reported were that the abnormal contacts were not made during normal masticatory movements, but could only be detected when the individual during the clinical examination was moving slowly from the endogenous postural position into occlusion. It has further been noticed that if the abnormal contact is removed, the individual rapidly reverts to the normal path of closure.

It was suggested that the masticatory movement which avoided the abnormal contact was a habit movement reflexly established as the result of the abnormal contact being made during idle mouth movement. If it was made during normal masticatory movement, it would certainly result in trauma to the supporting structures of the teeth, whereas the teeth that were the subject of these contacts were never clinically loose.

As the result of the work of Pfaffman (1939 a, b), and Stewart (1927), it was suggested that only very light contact was

necessary to initiate the afferent stimuli which produced the habit movement.

The finding of Hopper (1955) that the condyle is not displaced forward in Class III cases which have a postural element can easily be explained on this basis of the physiology of deviation from the normal path of closure.

The aetiology of these cases is that morphologically they are Class III but to a lesser degree, so that when the mandible moves through a normal path of closure, the first contact is an incisor edge-to-edge. This, reflexly and subconsciously, is not tolerated, and the mandible makes an avoiding action which is the apparent forward posturing.

From the generally accepted action of the muscles of mastication it may be suggested that the following is what occurs: at the point at which incisor contact would be made in normal masticatory movement, the posterior parts of the temporalis muscles relax, the lateral pterygoids pull forward the condyle, and the masseter muscles go into isometric contraction to prevent opening. As soon as the incisor contact has been avoided, the temporalis muscles contract again carrying the mandible upwards into an overclosed position.

There is invariably associated with this movement an excessive freeway space or interocclusal clearance.

The author has reported this in greater detail (Ballard, 1955) and, to quote, "the abnormal edge-to-edge incisor contacts made during idle movements of the mandible result in afferent stimuli from the pressure receptors in the periodontal membrane producing a protective habit movement of the mandible, which avoids this contact. This physiological mechanism also accounts for the constant finding of an excessive interocclusal clearance and overclosure in these cases. With a normal path of closure the occlusal level of the cheek teeth would be at about the level of the incisor edge-to-edge contact, but the normal pattern of activity which determines the occlusal level is reflexly disturbed. There is muscle activity to produce the deviation when there should be relaxation.

"Nevakari (personal communication) has found that the mandible in normal path of closure tends to rotate about a site which is downwards and backwards from the condyle. If this is so with the deviation under discussion, then this fact together with the overclosure would account for the finding that the condyles are not forward in the glenoid fossæ in the occlusal position. The rotation of the mandible has carried the condyles back after the forward disengaging movement.

"This, however, is a rather mechanistic explanation and the author would prefer a more physiological approach as follows: if the mandible reflexly moves forward to avoid the incisor contact, not only is there the extra motor activity to produce this movement but the main muscles of mastication are lengthened a fraction.

"It is endogenous within the neuromuscular mechanism to produce an occlusal level slightly closed from the rest position. The closing muscles are contracted and shortened from the rest position. This position can only be achieved after the forward disengaging movements by the mandible continuing to close (to an overclosed position) by rotating round a position downwards and backwards from the condyles. This movement also results in the repositioning of the condyle as previously described."

These findings and the theory as to the physiology of them are in accordance with the hypotheses put forward earlier in the paper. The mandible not only has a posture which is endogenously determined, but there are endogenously produced patterns of muscle co-ordination which result in so-called normal path of closure. Therefore, when the mandible moves in its endogenously determined path of closure into occlusion, it can be postulated that either the position of the cusps of the teeth, determined at least partly by the linguo-facial balance of soft-tissue activity, must result in a cuspal relationship which throws no lateral stresses on the dentition, or if lateral stresses are thrown on the dentition in true centric, then either:—

1. There is a reflex mechanism producing a habit movement—in other words, there is proprioceptive control of the endogenous patterns of activity; or

2. The habit movement is not formed and the teeth which are the subjects of the abnormal contacts will be traumatized.

Schweitzer (1951) has discussed this from the aspect of oral rehabilitation and refers to "centric jaw relation" and centric occlusion. If the latter is not in harmony with the former, then there may be "harmful effects".

The analysis made by Ballard and Grewcock (1954) also led them to suggest that the pain which was so frequently associated with mandibular displacement of the clinical types described, was most probably within the muscles and referred to the joint—the reflex activity, in other words, was disturbing the endogenous patterns of co-ordination, resulting in inco-ordination and strain. This view is supported by the finding that there are frequently tender areas in some of the muscles in such cases.

At this stage it is a good opportunity to refer back to the "physiological rest position", as described by Thompson. There is now no doubt in the author's mind that the distal path of closure which Thompson found in many Class II, Division I occlusal abnormality cases were not true distal displacements reflexly produced by abnormal cuspal contacts. The true explanation of this path of closure is that the mandible is habitually postured forward in order to enable the individual to maintain an anterior-oral seal across an increased overjet (Ballard, 1951a). This forward posturing also occurs in speech and any other activity which necessitates lip contact. Such a position of the mandible should be called a "habitutal postural position", as against the "endogenous postural position".

This is confirmed by the fact that, as has been shown by Ricketts (1952), the condyles are farther back in the glenoid fossæ at the end of treatment—in other words, the reduction of the overjet during treatment no longer necessitates the posturing forward of the mandible to help to bring the lips into apposition. Many individuals establish this habit of posturing forward as the result of conscious effort to close the lips across an increased overjet, particularly when they have an incompetent lip posture. This forward posturing has previously been discussed by the author (Ballard, 1951a).

It is also likely that a full and more careful investigation of our tongue thrusting (abnormal swallowing behaviour) cases will show that they can be divided into at least two types. It has been previously assumed (Ballard, 1953) that because most of the cases exhibiting this behaviour to a severe degree show no change of behaviour after orthodontic treatment and cannot control it by conscious effort, that all such cases are endogenous in origin. More recently, however, a careful analysis of cases out of retention after treatment has shown that some cases in which a tongue-thrusting behaviour was noted at the first diagnosis no longer exhibit the behaviour. From the original diagnosis, they are the types of cases in which the tongue thrust was not severe but as the result of other factors there was an increased overjet frequently associated with incompetent lip posture. It is too early to attempt to report fully on these two types. It is now likely that some of these cases are endogenous; they are those that do not improve as a result of treatment and cannot be improved by conscious effort. Those that do improve may be a habit behaviour, such a habit behaviour being reflexly established, to produce an anterior oral seal in cases of incompetent lip posture associated with an increased overjet, the anterior oral seal being produced by the tip of the tongue thrusting forward against the contracted lower lip, the upper lip being comparatively inactive. It has further been noted that in many of these cases they appear to drop the mandible from the endogenous postural position to enable them to push the tip of the tongue between the teeth against the lower lip. It is this type of case which has no gap between the lower incisor teeth and the upper incisor teeth or palate when the cheek teeth are in occlusion. If the explanation just given of this type of case is sound, then they should not be classified as having an abnormal freeway space or excessive inter-occlusal clearance.

Whilst discussing the endogenous postural position of the mandible, it should be mentioned that so-called "functional appliances'

work because they hold the mandible out of its true postural position. The central nervous system attempts reposturing from this position. This results in a pull on the body of the mandible which, transmitted to the teeth, is to all intents and purposes the same as intermaxillary traction. It is for this reason that Gresham (1952) found that in treated Class II cases the condyle was in its normal position at the end of treatment, although it was forward when the functional appliance was being worn at commencement of treatment.

Likewise, as has been previously mentioned by the author (Ballard, 1953), it is because the endogenous postural position of the mandible cannot be changed that functional appliances do not treat cases in the way that many authors state they do—that is by reposturing the mandible and altering patterns of motor activity.

In the light of this biological approach it is possible to speculate on the relationship between the facet formation in abnormal paths of closure, in cases of traumatic occlusion, and, what is probably a related mechanism, the marked attrition which is found in good occlusions.

It has been previously noted that very light pressure only is required to stimulate reflex avoiding action, but although it was postulated that the reflex activity was produced not by contact during masticatory activity but during idle movements, the author now thinks that it is likely that the facets seen in these cases could not have been produced by these idle movements, unless bruxism was present.

It is more likely that the facets are produced not by the teeth sliding across one another in contact, but by these surfaces of the teeth moving across one another in close proximity with food interposed. If this is so, then the marked attrition which one sees in good occlusions might be the result of the cuspal interdigitation as the occlusion developed, being in accord with the endogenous masticatory patterns of activity of the mandible. This permits full excursion and a maximum of movement of the surfaces of the teeth across one another, with food interposed. This is the evolutionary relationship between form and function as demonstrated by Mills in Primates (1955), which is no longer an important survival factor with present-day diets.

From our reasoning, we must accept the fact that any cuspal formation and occlusal relationship that is not in accord with the masticatory patterns of activity, will reflexly control the use of the endogenous movements. This is obviously what happens in extreme Class II, Division 2 cases, where no lateral excursion is possible, because of the excessive incisor and canine overbite; therefore, no attrition is found.

There is only one other habit activity which should be mentioned in connexion with abnormal cuspal relationship and that is bruxism. A theory for the establishment of this as a habit has already been put forward by the author (Ballard and Grewcock, 1954). It was suggested that it might be a reflexly established habit produced by cusps which interfered with the endogenous patterns of masticatory activity in an attempt to wear them away.

Finally, it can be pointed out that all the observations on the behaviour of the lips and tongue and clinical experience with their behaviour in relation to orthodontics, prosthetics, and periodontics which have been reported elsewhere by the author and others, such as Rix (1946, 1953), Tulley (1952, 1953, 1954), Hovell (1950, 1955), and Gwynne-Evans and Ballard (1947) support the hypotheses that have been put forward in this paper. To summarize, there is no evidence that the variation in tongue posture and behaviour can be re-educated. Any changes in behaviour that occur might easily be due to the fact that the behaviour noted before treatment was a reflexly established one, as for instance the lip tongue contact associated with a forward posturing of the mandible to produce an anterior-oral seal, when there is an increased overjet and incompetence of lip posture. Clinical observation indicates that incompetent lip posture cannot be changed, but that an individual may either reflexly maintain an anterior-oral seal by contraction of the orbicularis and metalis muscles, or in the

extreme cases, by conscious effort, teach himself to maintain an anterior-oral seal.

As has been previously stated, many of the cases with a vigorous tongue-thrusting behaviour also have an interdental sigmatism. This interdental sigmatism may either disappear from speech as the individual grows up or can be eliminated under the instructions of a speech therapist, but its elimination from the speech is not associated with any change in tongue behaviour which can be noted clinically, and the interesting thing is that the sigmatism returns when the individual is under stress or excited. This is similar to the experience with the training after nerve and tendon crosses.

SUMMARY

It is pointed out that previous theories and concepts on neuromotor behaviour (function) of the orofacial soft tissues have not been sound in relation to clinical experience.

The research work that has been done on the evolution, embryology, and development of behaviour is briefly reviewed. The general conclusions that can be drawn are that in the animal the basic patterns of motor co-ordination are endogenous in origin, determined as are other morphological characters by evolution. These basic patterns of co-ordination arise within the central nervous system and are not the result of reflexly stimulated trial-and-error learning; they cannot be eliminated, but can be modified reflexly to form habit patterns which are not permanently learned but have to be continually reinforced.

It has been shown how these principles can be applied to orofacial behaviour. They explain many of the recent clinical observations that have been briefly reviewed and offer a new approach to function in relation to orthodontic, prosthetic, and periodontal problems.

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DISCUSSION

Mr. Kettle made the observation that it was his belief that the occlusal arrangement of the teeth followed in the wake of functional movement and did not dictate it.

Mr. Elgey asked to what extent myofunctional appliances permanently changed the temporomandibular joint.

Mr. Hovell asked whether Mr. Ballard considered that the atypical swallowing patterns were truly endogenous and therefore probably hereditary or were they abnormal behaviour patterns acquired in utero at an early stage of development and therefore perhaps not endogenous but environmental prenatally.

Mr. Tulley said that he wished to take Mr. Ballard up on a number of points he had made. He entirely agreed with the basic concept that Mr. Ballard had put forward, but he did not believe that man could be compared with any other animal. The taking over of control by higher centres and the acquisition of habit movements was the very thing that made man different from animals. He said that it had been shown clearly by Weiss that after a tendon transplant in man, re-education by exercise could occur to enable normal function to take place. A dentist, after a few years of chairside work, tends to develop a poor posture generally and it is exceedingly difficult for him to revert to normal bodily posture even if it is endogenous. He thought it was wrong to dogmatize to the extent that Mr. Ballard had in this paper.

Mr. Jason Wood asked how much are we to try to persuade patients to overcome these endogenous ill-conceived postures? He thought he had been able to change patterns of behaviour in some of his patients, but perhaps his observations had not been sufficiently acute.

He would like to make a point by quoting a famous local duck. Normally a duck has two legs but this one was born with four, all of which it tried to use. It found walking very difficult until it had learnt to use two legs only and tuck the other two up under its wings.

Mr. Readings asked Mr. Ballard if he had any observations to make on the apparent overclosure in cases of partial anodontia.

Mr. Mills asked Mr. Ballard about the type of case of the fairly normal occlusion with the upper lateral incisors palatally placed and just inside the bite. The patient could just bite edge to edge on the upper lateral incisors. When these are pushed over the bite there is a definite overjet. He did not believe that these cases were overclosed. How did Mr. Ballard explain this type of case?

Mr. Walpole Day said that there was one aspect of postural Class III cases that had not been touched on. His own daughter had Class III tendencies towards the end of the deciduous dentition, and had enlarged tonsils and adenoids. Following the removal of tonsils and adenoids the upper lingual incisors had erupted to the lowers but without treatment had corrected themselves. He thought that the tonsils and adenoids were factors to be considered.

Mr. Ballard, in replying to Mr. Kettle, said he had raised an important issue and it was difficult to make an unprejudiced judgement as to which came first, the hen or the egg. To his mind, the biological background indicates that the patterns of activity came first and that either the cusps fit in with those patterns of activity or else the subsidiary proprioceptive mechanism described by Weiss control these patterns to avoid trauma in most cases. One cause of periodontal problems is that in some cases this mechanism does not protect the supporting structures of the teeth.

In reply to Mr. Elgey, he thought it possible that the position and the very shape of the condyles were determined by the endogenous patterns of activity. He thought it likely that the condyles were adapted to each individual's movement.

Mr. Hovell had raised a very important point indeed. He thought it was impossible in the time available for

him to deal with the possibilities of environmental influence in utero. It might be that the basic co-ordinating patterns of activity of the tongue are "imprinted" on the central nervous system at some brief and definite stage of maturation in utero by the sensory contact between say the tip of the tongue and the mucous membrane of the premaxilla. Any variation from the normal at this stage might "imprint" patterns of activity which we would call abnormal in the post-natal individual.

In reply to Mr. Tulley, in discussing the question of the learning of behaviour patterns man appears to learn to walk but what in fact happens is that as a process of maturation more complicated patterns of activity are built up in the central nervous system on the basis of the endogenous co-ordinating patterns. In training for special activity man may by conscious control modify the endogenous co-ordinating patterns of activity but these modifications were never permanently imprinted on the central nervous system.

With reference to tendon crosses he had made the point himself that man could overcome the disorganization, but only by conscious control after prolonged training, but the habit movement did not displace the endogenous co-ordinating patterns which would appear at any time that conscious control was lost. He had said that the monkey had not this conscious control.

He thought Mr. Jason Wood was probably not distinguishing between endogenous postures and patterns of activity and the reflexly established or habit ones. Probably all the changes in posture and behaviour associated with orthodontic treatment were either the elimination of reflexly established habits or the establishment of a habit to overcome an endogenous posture, or behaviour which was æsthetically or functionally unsatisfactory. The incompetent lip posture was a good example of an æsthetically and functionally unsatisfactory posture. After orthodontic treatment many individuals maintained for most of the time a lips-closed habitual posture by conscious effort. It did not matter for how long this was maintained, the muscles always had to contract from the endogenous posture of the open or incompetent position to produce a lip seal.

In reply to Mr. Readings he made the point that Mr. Hopper had already made, that it was the overclosure in these cases which gave the appearance of the mandible coming forward.

He thought that in the case that Mr. Mills had described the reflex posture to avoid those inlocked lateral incisors was so slight as not to fundamentally alter the endogenous pattern, therefore, there was no overclosure. With regard to Mr. Walpole Day's daughter, he thought that the best answer to this was that he had many Class III cases which had been put on the waiting list to push the incisors over the bite and after waiting some three or four months he had found that the incisors had come over the bite themselves. He thought that enlarged tonsils played no part at all in the production of these adverse incisor relationships.

VARIATIONS ON A SCHEME BY ANDRESEN

By **D. F. GLASS,** L.D.S., D.D.O.

THE name "Activator" covers a considerable variety of appliances which in turn have many different names—Monobloc, Norwegian, and Andresen are only three of the better known.

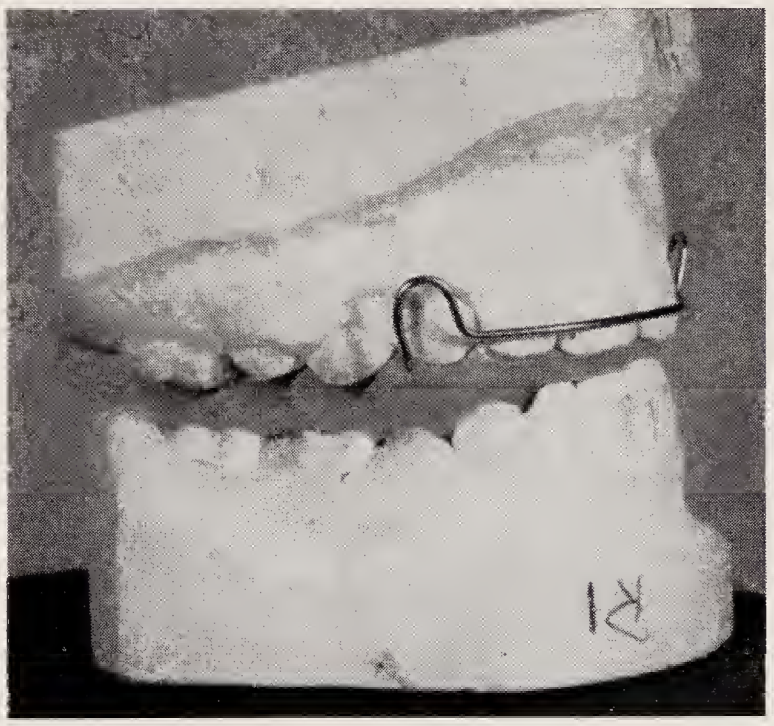

Fig. 1.—Shows monobloc with facets cut to allow upper right maxillary buccal teeth to move distally.

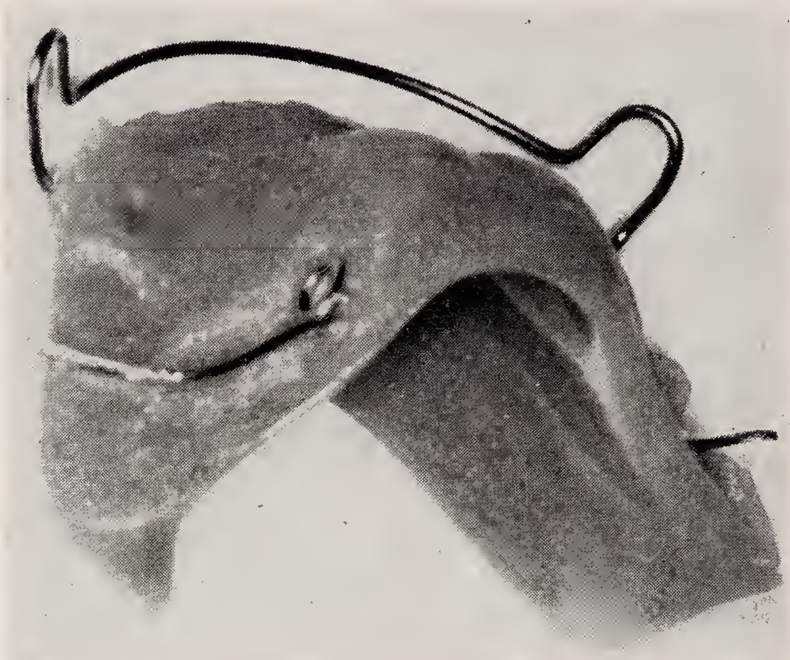

Fig. 2.—Monobloc with springs to move molars distally. Viewed from behind.

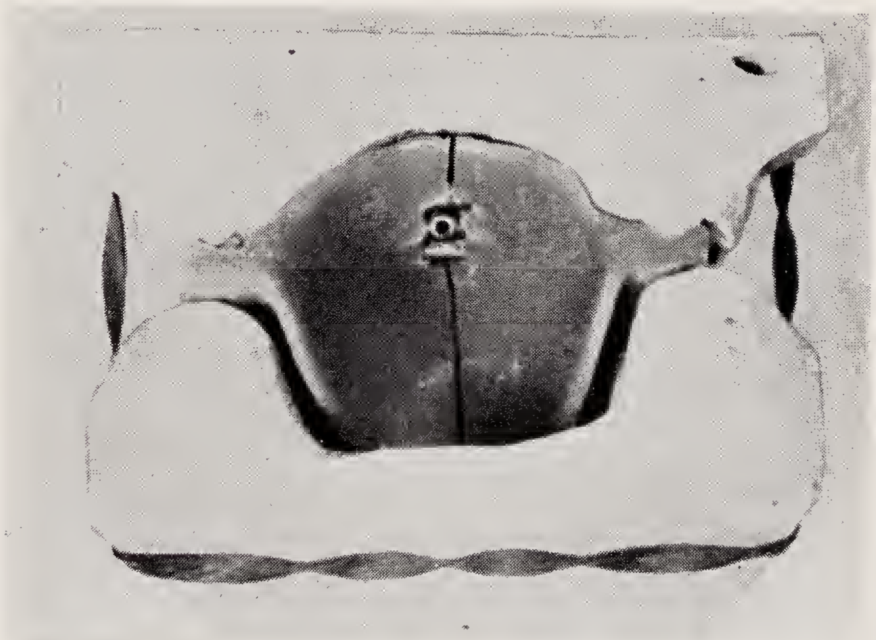

Fig. 3.—Monobloc incorporating expansion screw seen from behind; note the space in the lower half to permit upper expansion only.

Fig. 4.—Shows the divided monobloc united by 1-mm. stainless steel wire bent to permit adjustments.

These appliances range from the completely passive inert monobloc through a scale of elaborations and complications to the skeleton monobloc as described by Bimler.

The simple monobloc activator which employs only the cervicofacial complex of muscles to achieve its results is used in two ways in the treatment of inferior retrusion.

The facets on the appliance into which the upper and lower teeth fit are cut away to allow distal movement in the maxillary teeth and mesial movement in the mandibular teeth. Erupting teeth are guided into desired positions by means of the correct sloping planes of the tooth facet on the appliance (*Fig.* 1).

A demonstration at the Sheffield meeting held on May 7, 1955.

A refinement which can be most useful is the addition of molar springs on the activator which move the molars distally into precut

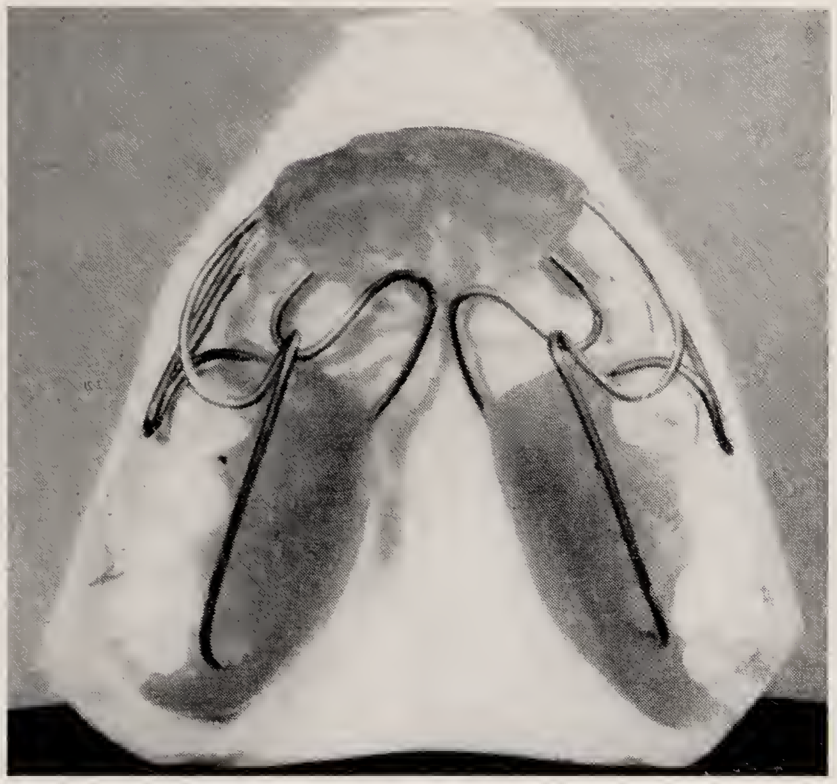

Fig. 5.—Bimler appliance fitted on the upper model as seen from below.

facets; this establishes normal molar relationship and assists distal movement of the upper premolars by the cut facets (*Fig.* 2).

The cutting of facets is not carried out by all operators, and many consider that the best results are achieved without cutting any facets except those to permit normal tooth eruption.

In many cases upper arch expansion is first necessary before intermaxillary traction. This can be achieved by incorporating in the activator an expansion screw or a 1·5-mm. coffin spring.

To avoid expansion of the lower jaw the lower half of the activator is relieved 1–2 mm. on the lingual side of the lower teeth, the whole activator being cut in two as for a simple expansion appliance. In this way upper expansion and intermaxillary traction are possible with one appliance (*Fig.* 3).

The extreme rigidity of the activator is considered by many to be a disadvantage, and less rigid activators which permit latitude of individual jaw movement are becoming more popular. These vary considerably in design and construction; the basic principle is that the two halves, upper and lower, are united by a wire or wires.

Fig. 4 shows a simple type in which the two halves are processed separately and united by a spring or double-U of 1-mm. stainless steel

Fig. 6.—Bimler appliance seen from above and right side.

Fig. 7.—Side view of Bimler appliance; note the upper labial arch and the cut lingual arch, also lower labial arch with capping for incisor teeth.

wire. The incisal tips of the lower teeth may be capped and the lower labial arch included.

The activator as described by Bimler and its various adaptations seem to be approaching the ideal physiological appliance; they give encouragement to correction and offer gentle persuasive action. A typical Bimler appliance is shown in *Figs.* 5–7.

Thanks are due to Mr. Clementson and the Photographic Department of the Plastic and Jaw Injury Hospital, East Grinstead, for the photographs.

SPEECH DEFECTS AND MALOCCLUSION: A PALATOGRAPHIC INVESTIGATION

By **G. B. HOPKIN** and **J. D. McEWEN**
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PALATOGRAPHY is the recording of the contacts made by the tongue during speech with the teeth and palate. The pictorial record of a particular tongue contact is called a palatogram. It is one of the methods used by phoneticians for the study of speech sounds. There are two methods of palatography (Abercrombie, 1955)—the Direct and the Indirect; both were originated by dental surgeons, the Direct Method by Oakley Coles (1872) and the Indirect by Kingsley (1880). Both Oakley Coles and Kingsley studied the mechanics of speech production in order to be able to give speech training to their cleft-palate patients.

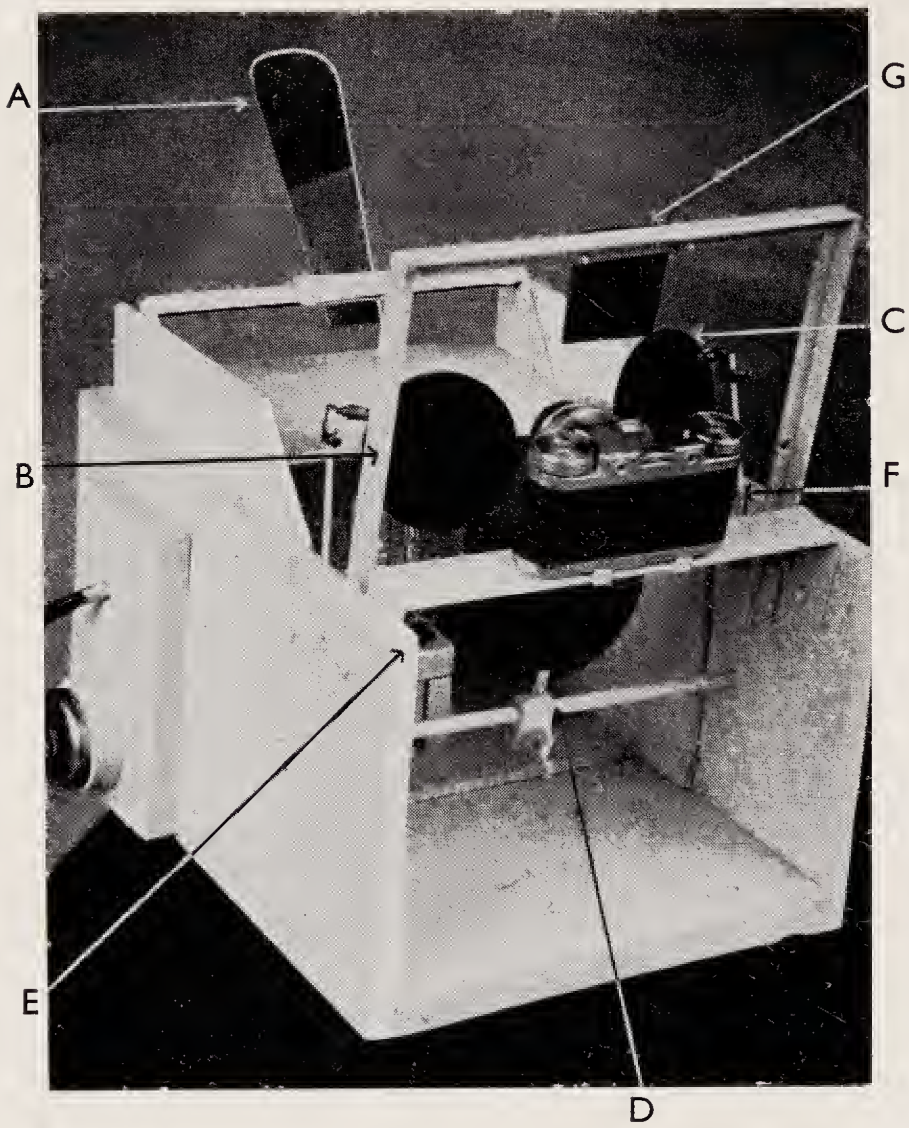


Fig. 1.—The apparatus (for description *see* text).

Oakley Coles made casts of his upper and lower jaws and from engravings of the casts had prints made. He painted his palate with a mixture of gum and flour, enunciated a letter, and recorded the contact areas, shown by removal of the gum-flour mixture, with red paint on a print. He repeated this procedure for each letter of the alphabet. His article is illustrated with twenty-six beautifully reproduced colour prints of both upper and lower arches and also shows the lip positions for each letter.

Kingsley made a plate of black vulcanite covering the hard palate. The plate was painted with a mixture of powdered chalk and alcohol, placed in the mouth and a sound uttered, the plate was removed, the contact areas or "wipe off" were delineated on a cast and a drawing made later of the cast.

Witting (1953), in a brief review of the subject, says that after some use of the direct method, the indirect method of Kingsley became of general use among phoneticians, the artificial palate being placed on a cast of the subject's mouth and photographed. The disadvantages of this method were several; contacts made with the soft palate could not be recorded; an artificial palate had to be made for each subject; the presence of the plate was liable to cause distortion of the patient's speech.

The direct method of Coles was used by Carruthers (1899, 1900); his use of the method was similar to that of Coles, but Carruthers made an improvement by using powdered charcoal instead of the gum-flour mixture.

The great advantage of the direct method was that its use entailed no interference with the subject's usual speech and a large number of subjects could be examined in a short time.

The disadvantage, which presumably was responsible for its neglect, was the difficulty of recording the contact areas. This difficulty was overcome by Anthony (1954), who

A demonstration at the Sheffield meeting held on May 7, 1955.

developed an apparatus by means of which a photographic record of the subject's hard and soft palates could be made simply and quickly. Witting has also reported a method of photographing the palate, but unlike Anthony's method it cannot be used single handed; he painted the tongue with a mixture of charcoal and grape sugar, charcoal being deposited on the palate at the areas of contact.

A B

Fig. 2.—A, Palate after spraying; B, Sprayed palate after making *s* sound.

Description of Apparatus (*Fig.* 1).—The apparatus consists of an elongated plane mirror A over which the subject places his mouth. Convex mirrors B, C, and D, focus light from a 500-watt projector bulb E on the area of mirror A within the mouth. The image of the palate in the mirror A is photographed by a 35-mm. camera mounted at F. The subject can see his palate in the plane mirror G.

Method of Use.—The palate of the subject is sprayed with a mixture of powdered medicinal charcoal and chocolate powder, 3 parts of charcoal and 1 part of chocolate. The subject then utters the sound under investigation and without swallowing places his mouth over the mirror and the palatal picture is recorded with the camera (*Fig.* 2 A, B). Care must be taken to see that the subject does not exhale and fog the mirror.

Anthony incorporated a compressed-air unit for spraying the palate, but we found an ordinary rubber bulb insufflator satisfactory and probably preferable when children are the subjects. We also found a fifty-fifty mixture satisfactory for recording and more palatable to the children.

DEVELOPMENT AND PHYSIOLOGY OF SPEECH

In order to interpret palatograms an understanding of the mechanics of speech production is necessary. In spite of the increasing stress laid upon function in orthodontics to-day, no account is given, in the standard orthodontic texts, of the part played by the masticatory and respiratory systems in speech. With the exception of a brief description by Izzard (1950) one has to turn to Kingsley (1880) or Case (1921) for any account of the mechanism of articulate speech, and we have felt it desirable to give a brief account of the development and physiology of speech.

The development of speech therapy and contact with speech therapists has quickened the interest of orthodontists in speech defects.

White, Gardiner, and Leighton (1954) refer to the value of speech therapists in correcting tongue habits; Henry (1937) suggests speech therapy as an aid in the retention of treated distocclusion cases, and there are several articles in American orthodontic literature

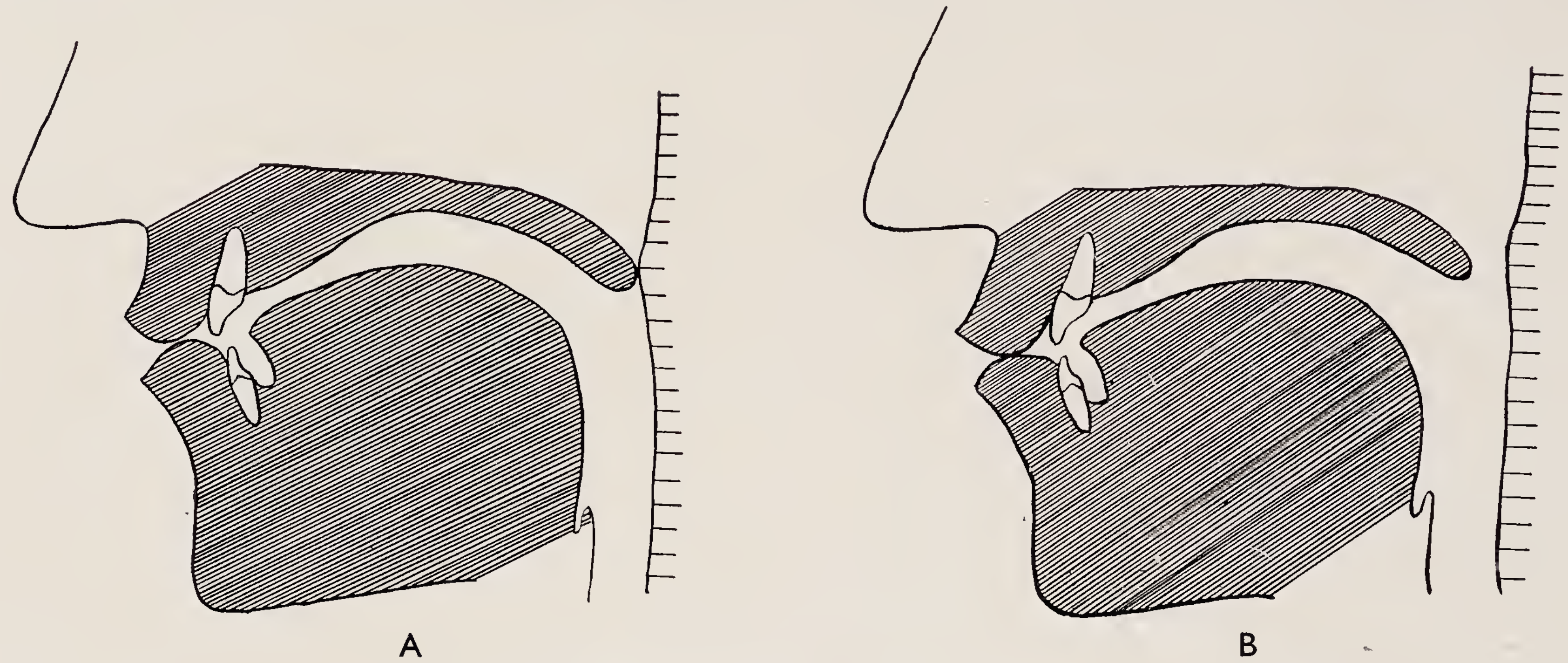


Fig. 3.—A, Lip contact in plosives *p* and *b*; B, The *m* sound (note nasal escape).

written by, or in collaboration with, speech therapists on the relationship of malocclusion to speech defects.

Development of Speech.—Whilst man may have an inborn instinct for some form of

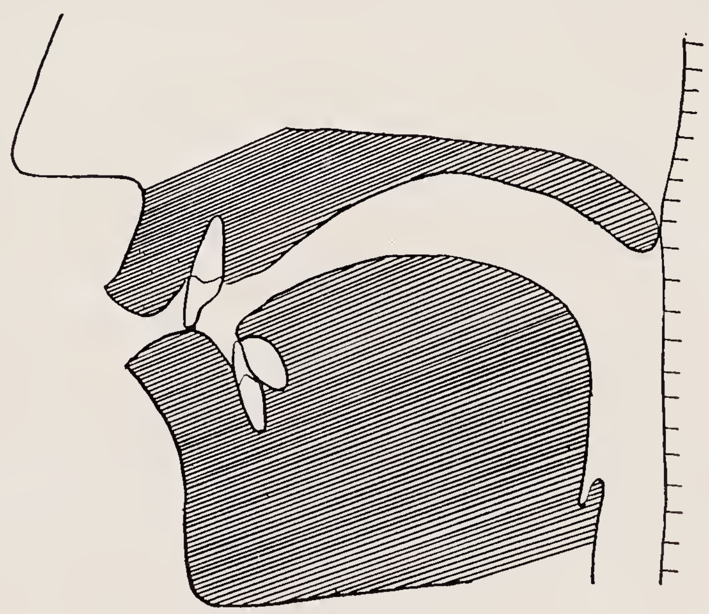


Fig. 4.—Linguodental fricatives *f* and *v*.

expression by which emotions can be expressed, as is shown by the different cries of a baby to express hunger, anger, or pain, man does not speak by instinct; articulate speech has to be learnt.

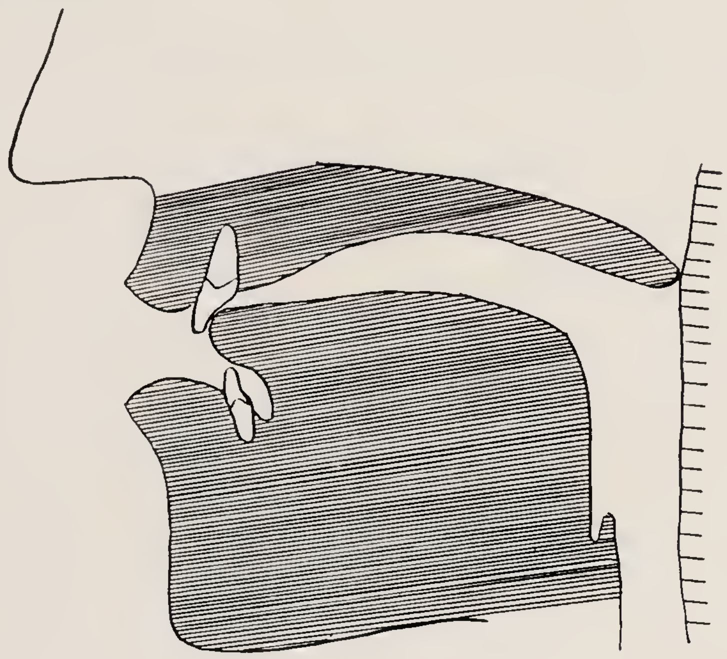
The learning and perfection of speech parallels the development of occlusion in the deciduous and early stages of the mixed dentition, beginning about the fifth month. While most children are "talking" by three years of age, complete mastery of all consonantal sounds is not to be expected until later, particularly the *f*, *th*, *s*, *sh*, and *zh* sounds. Both Gardner (1949) and Rathbone (1955) state that many children do not perfect the formation of these latter sounds until they are seven. The development of normal speech of course depends on the normal development and innervation of the anatomical parts involved in its production, including normal hearing, as the process of speech learning is mostly by the imitation of sounds heard.

Physiology of Speech Sounds.—Speech sounds are normally made during expiration, the expressed column of air being vibrated by the vocal cords to produce the vowel sounds and the voiced consonants. The unvoiced consonants and the consonantal content of voiced consonants are produced by stopping or modifying the passage of the air-stream. This interference is produced by the action of the lips, teeth, tongue, or soft palate. The size and shape of the mouth and nasal cavities affect the resonance and tone of the speech sound.

Before considering the mechanism of the production of specific speech sounds it should be emphasized that, to quote Kingsley (1880), "it is not supposable that all persons making the same sound place the active accessory organs in the same identical position . . . exactly the same resonating cavity in shape is

not likely to exist in any two jaws . . . and the changeable portions such as the tongue and soft palate adapt themselves to the circumstances and produce a resonating cavity of the same tone character".

As this study is only concerned with the relationship of speech sounds to the dental structures, vowel production is not described in detail.



A

B

Fig. 5.—A, B, Linguodental fricatives.

The terminology used by various authors to describe speech sounds varies considerably. We have based our own on that used by Seth and Guthrie (1935) and Twitmyer and Nathanson (1932).

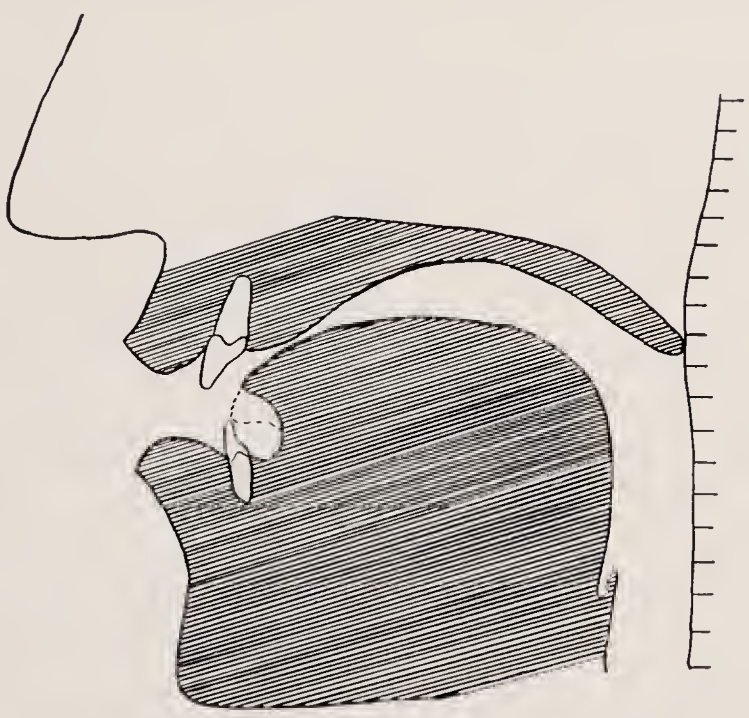


Fig. 6.—Tongue positions for *s* sound.

Divisions of Speech Sounds.—*Consonants* may be Oral or Nasal, voiced or voiceless. Consonants are produced by either vibrated or unvibrated air passing through the larynx obstructed, interrupted, and modified by the tongue, lips, teeth, and palate—*c*, *g*, *p*, *f*, *d*, *ng*.

Vowels are sounds which are produced by vibrated (voiced) air passing through the larynx uninterrupted by the lips, tongue, or teeth; the soft palate by contacting and sealing the pharynx with the aid of the pharyngeal musculature allows none of the vibrated air to pass into the nasal cavities—*a*, *e*, *i*, *o*, *u*.

Consonants are classified both according to the parts of the mouth employed and according to the mechanics of their production. For example, the sounds *p* or *b* are made by closing the lips together, building up air pressure behind them and then suddenly releasing the air with explosive effect. Consonants *p* or *b* are therefore classified as bilabial (location) plosives (dynamics).

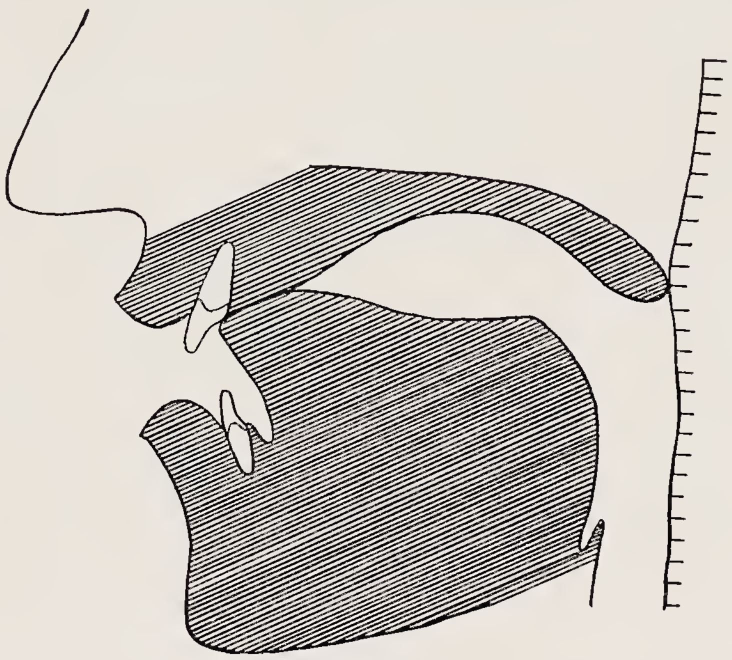
The main consonantal divisions are as follows: the tongue and lip placements will be seen in the accompanying diagrams and palatograms; note that for all except the nasal consonants (*m*, *n*, *ng*) the soft palate seals off the nasopharynx and nasal cavities.

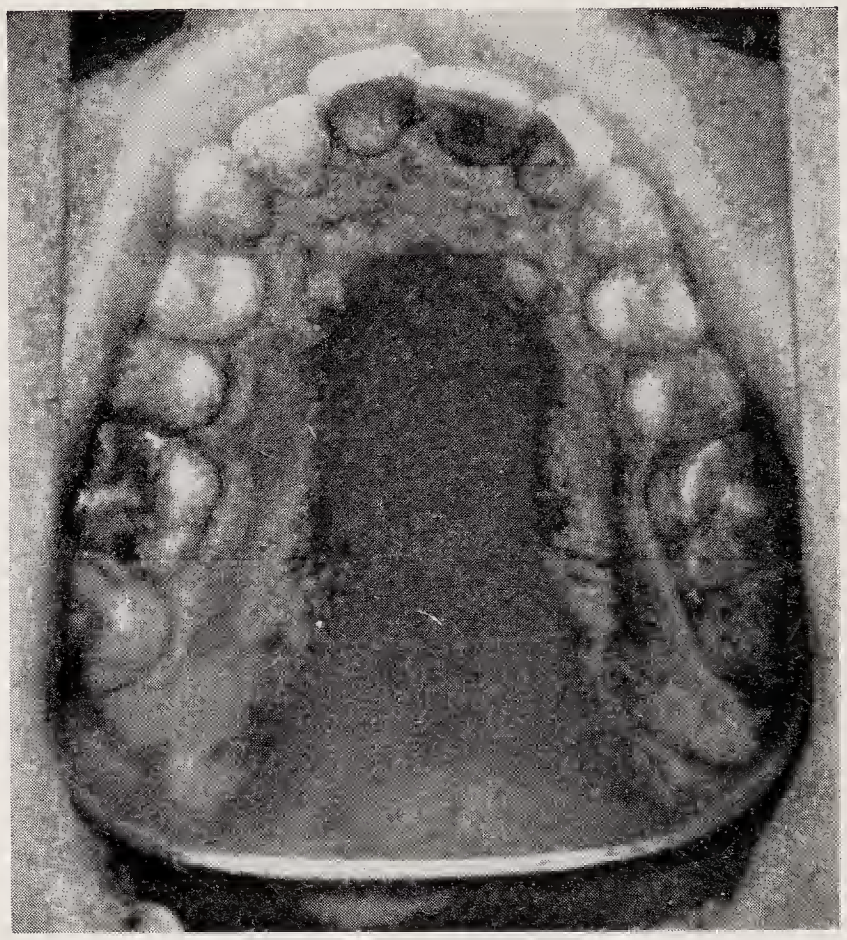
1. *Bilabial Plosives p*, *b*, *m*, are produced as described above (*m* is not a true plosive, having nasal escape) (*Fig.* 3 A, B).

2. *Labiodental Fricatives f, v* ($v = f$ voiced). The lower lip is placed against the incisal edge of the upper incisors and the air-stream forced out between them, the friction set up producing the sound (*Fig.* 4).

3. *Linguodental Fricatives th* sounds, voiced and voiceless. The tip of the tongue is placed against the palatal surfaces and tips of the upper incisors (*Fig.* 5 A, B).

4. *Linguo-alveolar Fricatives s, z* ($z = s$ voiced). The tip of the tongue is placed behind the upper or lower incisors, the edges of the tongue contacting the lingual surfaces of the cheek teeth and the gingival area of the palate, the air being expelled through the narrow anterior channel (*Figs.* 2 B and 6).





A B

Fig. 7.—A, Linguo-alveolar plosive; B, Palatal *t* sound.

5. *Linguo-alveolar Plosives t, d, n* (*n* has nasal escape). The tongue position is the same as for *s*, but the anterior channel is blocked (*Fig.* 7 A, B).

6. *Alveolar Lateral, l.* The tongue contacts the premaxillary area and the air-stream escapes over the sides of the tongue (the tip of the tongue is in the same position as for *t*, for example as in "little") (*Fig.* 8).

7. *Palato-alveolar Fricative sh, zh,* are produced similarly to linguo-alveolar fricatives with the tongue farther back.

8. *Velar Plosives, k, g, ng* (nasal voiced), *k,* and *g* sounds, are made by pressing the back of the tongue against the soft palate and quickly lowering the tongue with slight plosive effect. For *ng* the soft palate is lowered to contact the back of the tongue and the air-stream passes out through the nose (*Fig.* 9 A, B).

Each sound, consonant or vowel, has its own wave form, but those of consonants such as *p, b, t,* and *d* are so short that no sensation of pitch is given by them, but sibilant consonants *s* and *z* may last as long as vowels or longer. It is particularly with the *s* sound that variations of frequency are noticeable.

Fig. 8.—Palatograph *l* sound.

Kimball and Muyskens (1937) point out that the static positions used to describe consonantal mechanics are but momentary positions of the muscles concerned. They stress the importance of the co-ordinated activity of the circularly and longitudinally arranged muscles of the mouth, pharynx, and larynx in producing the necessary alterations in the size and shape of the speech tube for the formation of the various speech sounds.

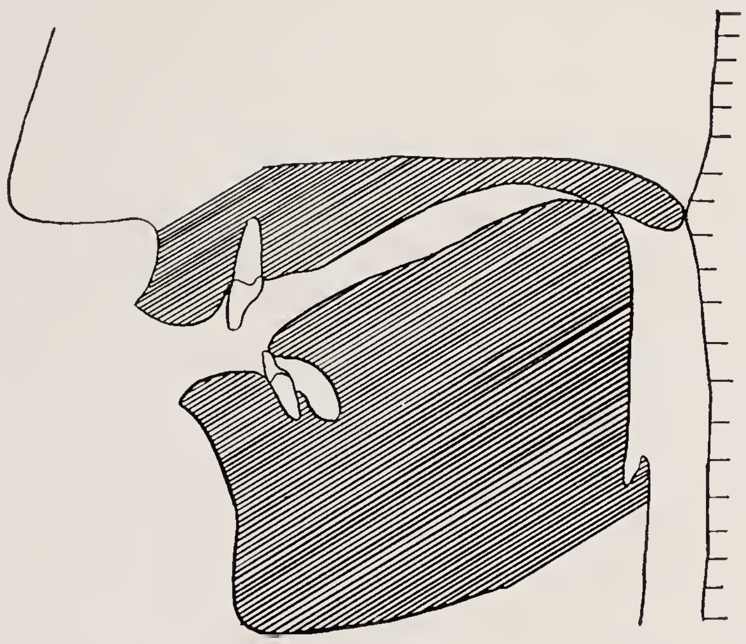
RELATIONSHIP OF SPEECH DEFECTS TO MALOCCLUSION

Review of Literature.—Since 80 per cent of specific speech movements are made in the anterior part of the mouth (Kimball and Muyskens, 1937; Ramsay, 1937), it is not therefore surprising that a causal relationship between speech defects and malocclusion has long been assumed to exist. Farrer (1888) describes a case of speech improvement following correction of an incisal irregularity, and Angle (1907) refers to the ill effects of malocclusion upon speech. Articles such as those by Hellman (1917), Wepman (1937), and Kessler (1954) commonly list Angle's Class II and Class III malocclusions, narrow high palates, incisal irregularities, spaced or absent teeth and open bite, as the malocclusions chiefly associated with defective speech. The speech sounds said to be affected are the bilabial, labiodental, linguodental and linguo-alveolar consonants in the anteroposterior anomalies; the palatal consonants in cases of high palate; and the very common defect, the defective *s* sound or sigmatism, is associated with irregular incisors and anterior open bite.

The correlation between defective speech and malocclusion is not, however, absolute; as Hellman (1917), Wray (1952), and others have pointed out, defective speech may be found with good occlusion and good speech with marked malocclusion, there being other factors such as level of intelligence, emotional state, social conditions, etc., which influence the ability of the patient to adapt the flexible parts of the organs of speech to compensate for the defects of the rigid parts. Downey (1943) contends that 90 per cent of speech disorders are functional in character and present primarily an educational problem.

Out of 180 orthodontic patients examined by Van Thal (1935) 90 per cent had errors or defects of speech in varying degree, but she considered that although bad dentition has an unfavourable influence on speech we are not justified in regarding it as the actual cause of such articulatory defects as lisping.

Bernstein (1954), in a study of 437 children with defective speech, compared the incidence of malocclusion in them with that of a control group of 446 children with normal speech.



A

B

Fig. 9.—A, Velar plosives; B, Palatograph sound hard *g*.

Statistical analysis of his findings showed that speech defects were not related to malocclusion except for the condition of open bite, which showed a strong relationship with lisping, but the severity of the lisp was not related to the degree of the open bite.

Ramsay (1937), in a study using indirect palatograms, found 80 per cent of lispers had a malocclusion. Rathbone (1955), in collaboration with a speech therapist, examined casts of ten patients and tried to predict the speech defect from the malocclusion, but he found no direct relationship between the severity of the speech defect and the malocclusion. He refers to an unpublished thesis by Bruggeman (1934), who surveyed 477 children aged 4–8 years and found that 65 per cent of the total and 87 per cent of the defective-speech group had a malocclusion. Further findings were that spacing of the teeth and high palates were more common among defective speakers.

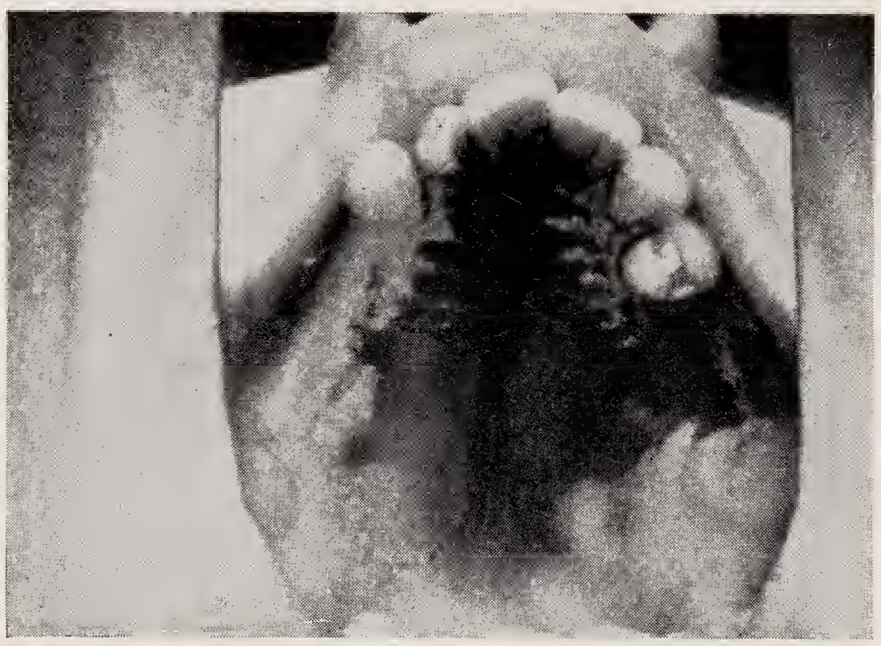


Fig. 10.—Lateral escape of air-stream during *s* sound.

It will be seen that the age groups examined by Bruggeman, i.e., 4–8 years, cover mainly the period during which a child is acquiring mastery of consonant production, and as both Rathbone (1955) and Gardner (1949) state, *s* sounds, one of the most common speech defects, are mastered last. Bearing in mind also the range of variation in terms of chronological age at which a particular child reaches a specific "developmental age", one can expect to find in such a group of children a large number whose speech is still in the developmental stage.

The shedding of the deciduous incisors and the eruption of their permanent successors takes place during the latter part of this period (4–8 years), and temporary difficulties, particularly with *s* sounds, may occur at this time. Orthodontically it is a period during which malocclusions of a transient nature may arise which are self-correcting with further development.

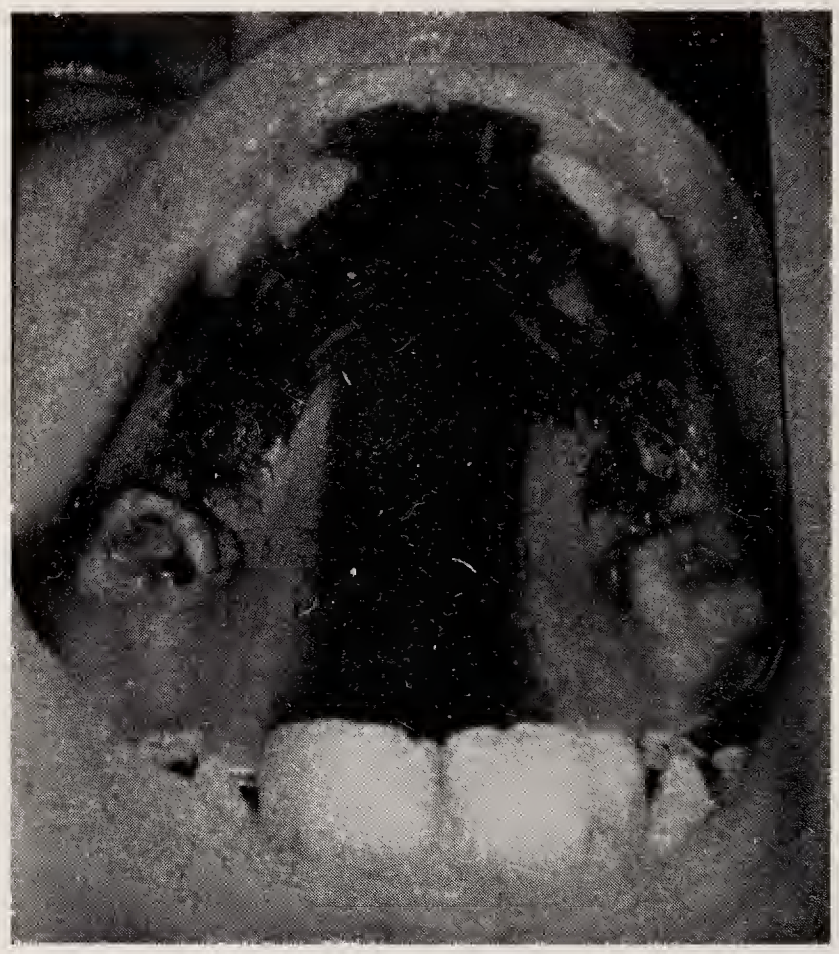


Fig. 11.—Large anterior and lateral escape of air-stream during *s* sound.

Abnormal speech as a cause of malocclusion is mentioned by Strang (1950), who considers lisping to cause labioclination and infra-occlusion of the incisors. Greene (1937) also observed that in 92 per cent of all cases of lateral lisp the larger arch was on the lisping side. These cases would appear, in the light of recent work on swallowing, to be basically ones of atypical swallowing which can produce the dental irregularity described and may predispose to lisping.

In this connexion the observation by Schorr (1939) of different patterns of tongue movement in breast-fed and bottle-fed babies is interesting; he suggested a connexion between the forward thrusting of the tongue in the bottle-fed babies and the incidence of lisping. It is possible that he was observing the normal and atypical swallows, but failed to

realize it, owing to his pre-occupation with breast versus bottle feeding.

Clinical Findings.—Patients with extreme conditions of Angle Class II and Class III jaws are responsible for causing speech defects, owing to the difficulty of effecting the usual placements of the tongue, lips, and teeth for the production of many consonantal sounds.

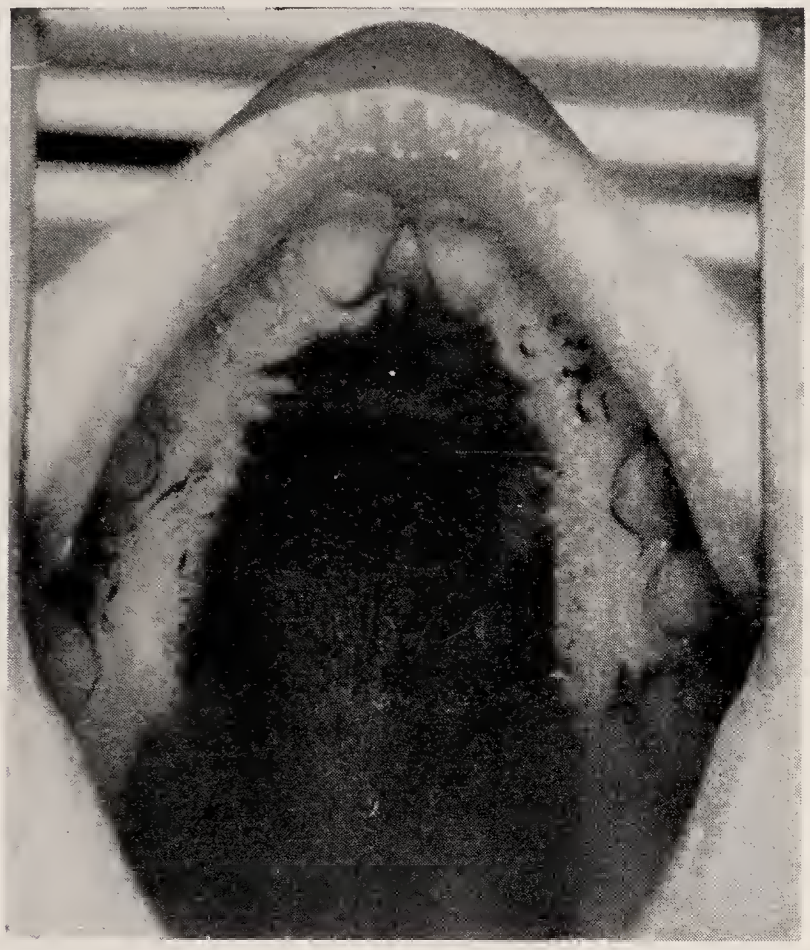


Fig. 12.—Normal *s* sound with anterior open bite.

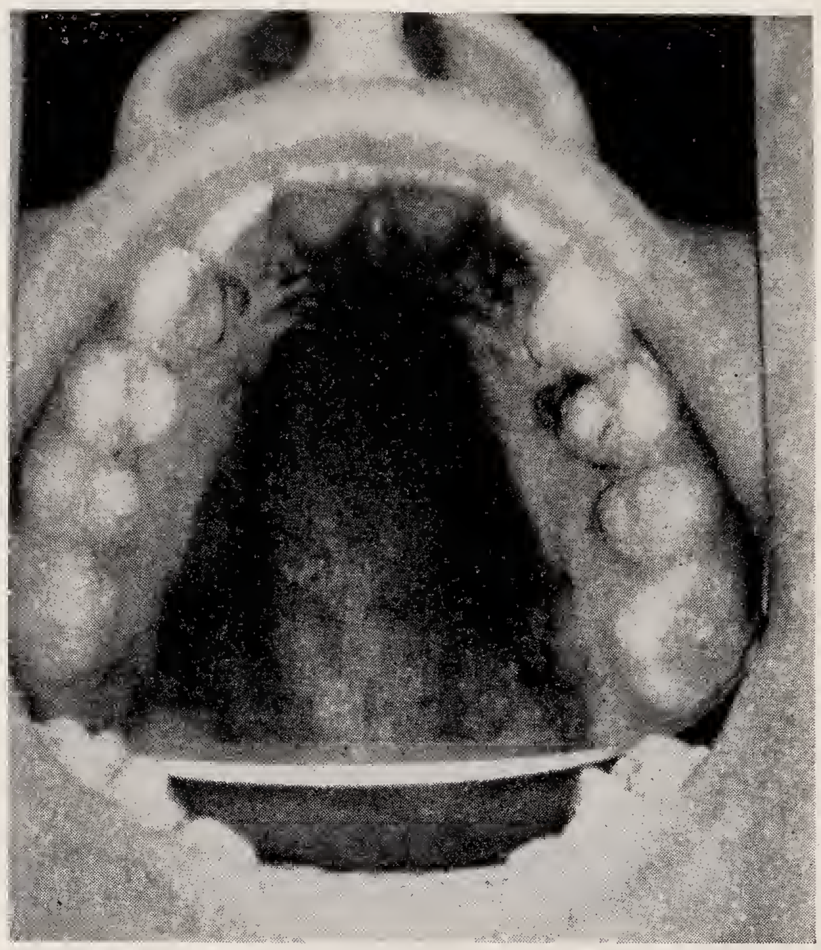


Fig. 13.—Open bite with lisp.

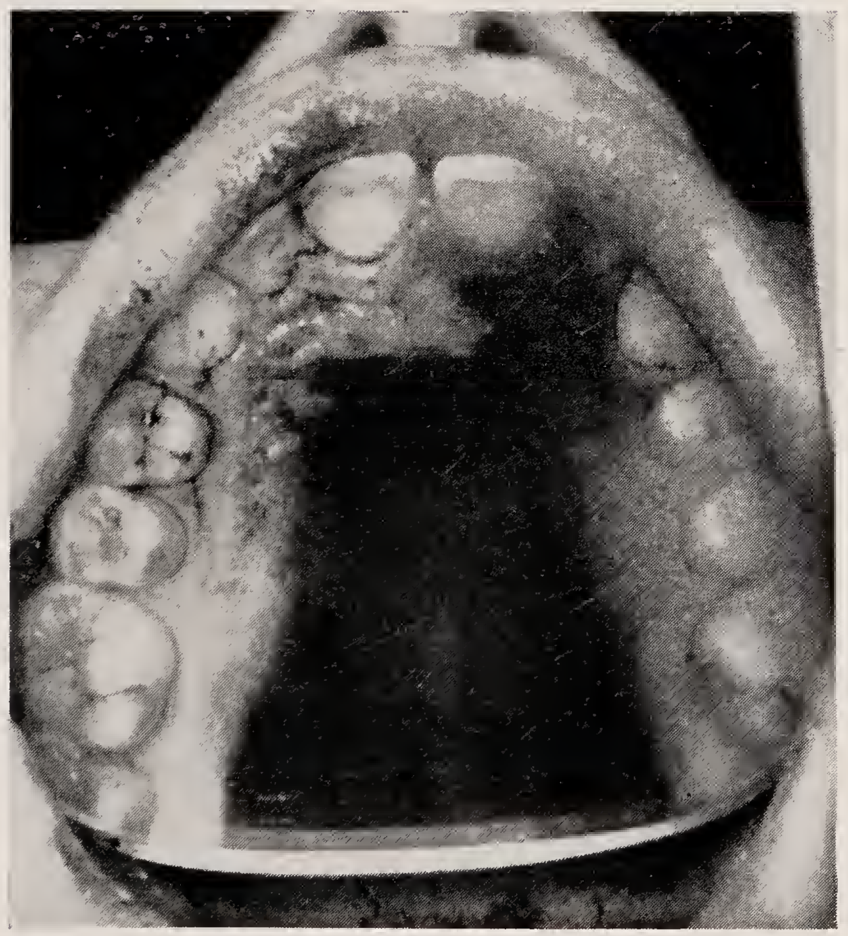


Fig. 14.—Lateral escape *s* sound with "normal" occlusion.

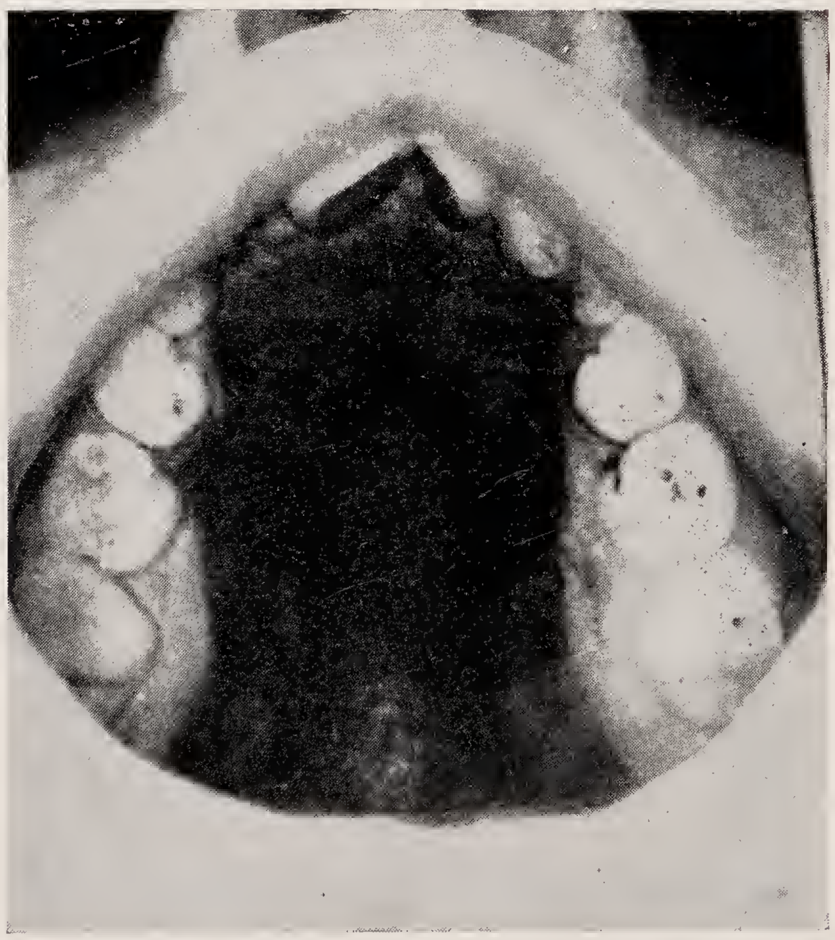


Fig. 15.—Lisp in case of excessive over bite.

malocclusions were examined, as it is in these cases that it is generally held that the antero-posterior malrelationships of the teeth and

Case 1.—This patient had an orthodontically untreatable Class III malocclusion. Greene observes that in such cases the labiodental sounds are made in reverse, the lower incisors contacting the upper lip; however, this

patient was able to retract his lower lip up over his lower incisors to make the correct contact with his upper lip and teeth for the bilabial and labiodental consonants.

The palatogram of his *s* sound (*Fig.* 10) shows lateral escape of the air-stream without any marked effect on the sound produced. The tip of the tongue lay on the lower incisors and the tongue was longitudinally grooved to produce the narrow channel required. When making the *t* sound the dorsum instead of the tip of the tongue contacted the upper incisors.

The speech of this patient, who was a university student, was without noticeable defect.

Case 2.—A case of Angle Class II Division I, with mandibular under-development. This patient had a lisp, the palatogram for *s* (*Fig.* 11) shows a large anterior and lateral escape of the air-stream. The bilabial consonants were defective, the upper lip was short and atonic, and the lower lip contacted the upper incisors as for a labiodental consonant.

Case 3.—This patient had an anterior open bite, the palatogram for *s* (*Fig.* 12) shows a normal channel, and there was no speech defect.

Cases 4, 5, 6.—All these patients had marked lisps. *Case* 4 had an open bite and the *s* palatogram (*Fig.* 13) shows a wide channel compared with *Fig.* 12.

In *Case* 5 the arches are well formed with normal occlusion, the *s* palatogram (*Fig.* 14) shows a wide lateral channel; this patient was apparently unconscious of her speech defect and did not desire speech therapy.

Case 6 had an excessive overbite, the palatogram for *s* (*Fig.* 15) shows an abnormally wide channel resembling the palatogram for *th* (*Fig.* 6 B).

It will be seen from these examples that while, on the one hand, as other observers have already noted, malocclusions can be obstacles to normal speech, and these obstacles can be overcome given intelligence and conscious effort, on the other hand good occlusion can be accompanied by defective speech.

The present study is being continued and it is hoped to publish further findings.

We wish to acknowledge our indebtedness to Mr. D. Abercrombie, Head of the Phonetics Department of Edinburgh University, for facilities for reproducing Anthony's apparatus, which was developed in his Department; and to Mr. J. P. Ladeforged, also of the Phonetics Department, for valuable advice and criticism.

We also wish to thank Mr. W. Duncan, our Instructor Technician, for constructing the apparatus and for assistance with the photography.

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A LINGUAL APPLIANCE FOR MESIODISTAL TOOTH MOVEMENT

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Orthodontic Department, Turner Dental School, Manchester★

This appliance is particularly useful for the unilateral or bilateral retraction of lower canines and premolars, although any incisor, canine, or premolar may be moved along the line of the arch in the same way.

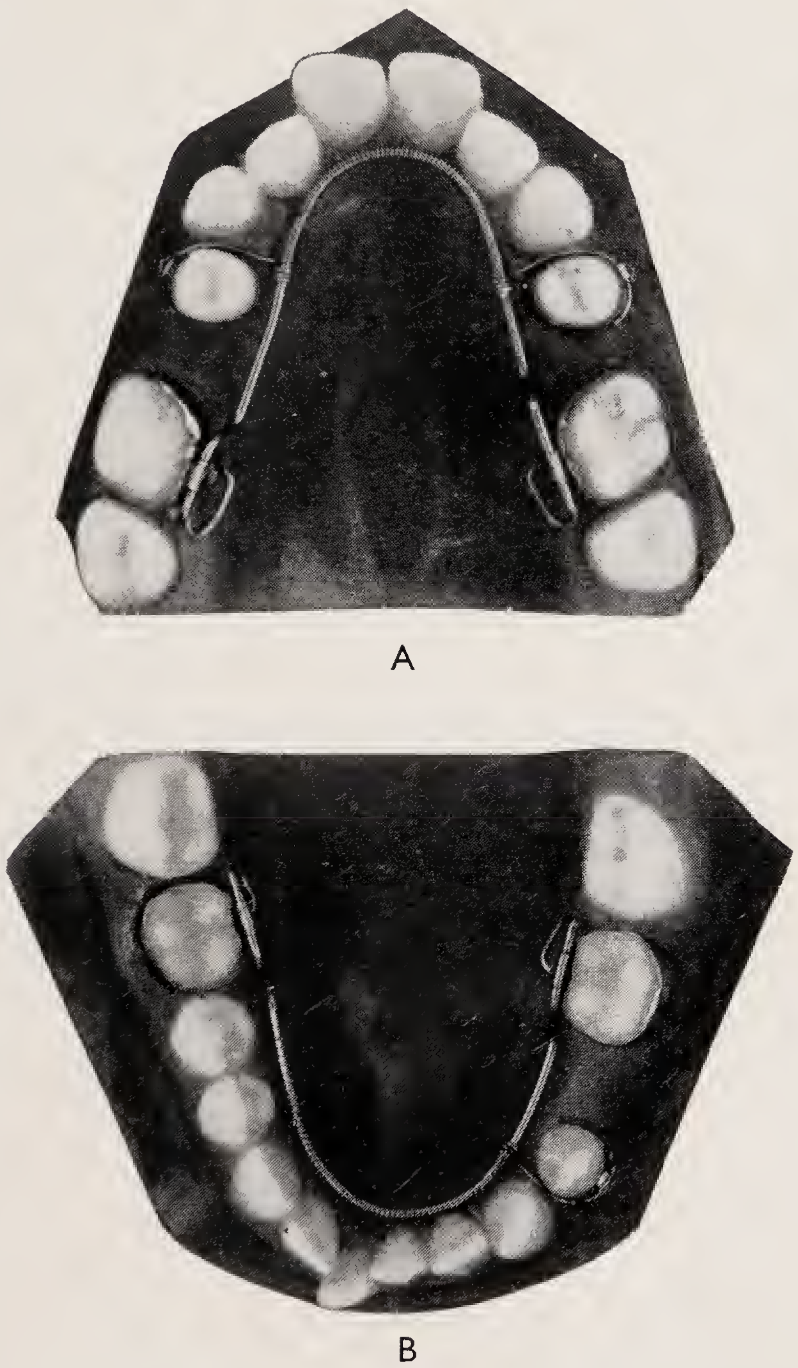


Fig. 1.—A, Upper appliance. Bilateral retraction using reciprocal spring action. B, Lower appliance. Unilateral spring action. Note the small stop on the lingual arch in $\overline{43}|$ region.

It is not suitable in the upper arch in cases with an excessively deep overbite as the lower incisors tend to bite on it.

The appliance consists of a lingual arch in 1-mm. round wire attached to bands on the molar teeth in the usual way.

This arch carries a sliding arm (or two, if bilateral movement is required) made by wrapping 0·4-mm. wire around the lingual

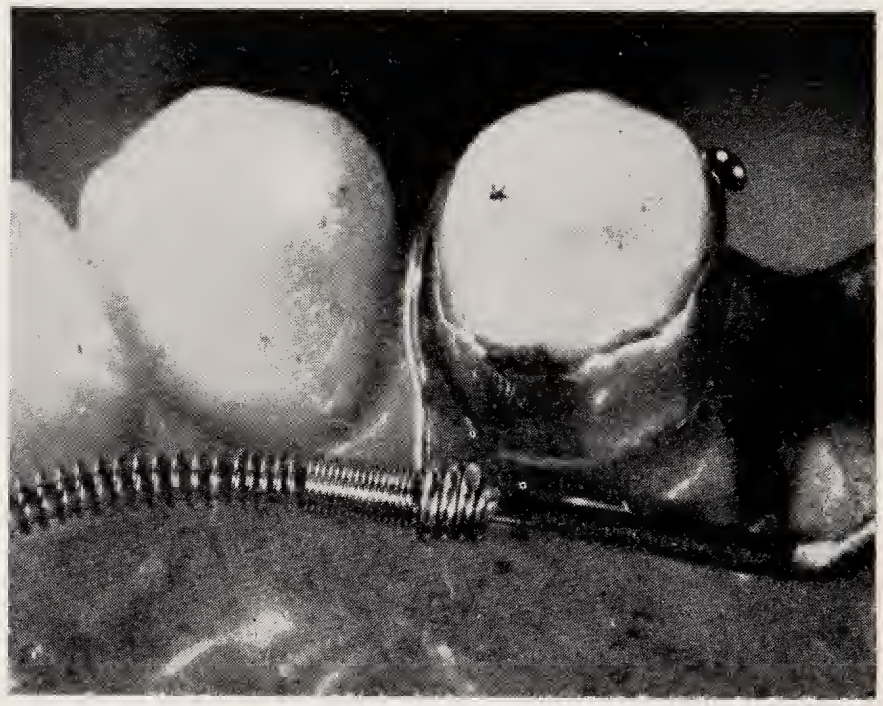


Fig. 2.—Close-up of sliding arm and one end of the compression spring. Note the unactivated portion of spring next to the sliding arm, kept for adjustment in bilateral retraction cases.

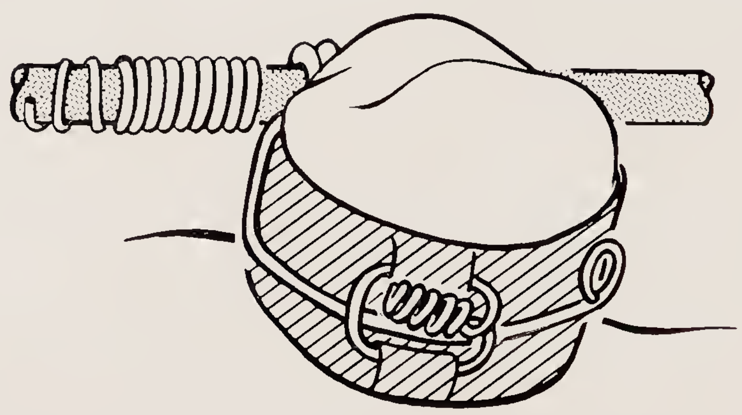


Fig. 3.—Twin wire arch channel with sliding arm ligatured to it.

arch and leaving one end projecting to hook round the tooth to be moved (*Figs.* 1, 2). To prevent this arm slipping off the tooth, it is ligatured to a twin wire arch channel attached to the tooth (*Fig.* 3).

★ The author has now joined the staff of the Orthodontic Department, Liverpool Dental Hospital.

A demonstration at the Sheffield meeting held on May 7, 1955.

Pressure is provided by a coil spring of 0·15-mm. wire wound on 0·9-mm. wire. Activation is achieved by stretching this beyond its elastic limit, on 1-mm. wire, and then compressing it again as much as possible. In this way all the coil springs used are activated to more or less the same degree.

Fig. 4.—Drawing of the stop on the lingual arch. Note the compression spring, active on one side and passive on the other.

Fig. 5.—Composite spring showing how the two halves wind on to each other.

In unilateral cases the spring works against the sliding arm at one end and against a small stop of 0·7-mm. soft wire at the other. This is welded to the lingual arch out of the way of the tongue in the opposite canine or premolar region (*Figs.* 4, 1B). The pressure of the coil spring on the sliding arm can be rapidly adjusted by screwing the spring past the stop, increasing or decreasing the amount of spring between the stop and the sliding arm. In bilateral cases this technique is not used. Instead, the spring action is reciprocal between the two sliding arms (*Fig.* 1A). If adjustment is required in these cases, any of the following ways may be used:—

1. A previously unactivated portion of the coil spring may be opened (*Fig.* 2).
2. New lengths of coil spring may be wound on to the lingual arch.
3. The spring on the lingual arch is initially in two halves which are wound into each other. To increase the activation of this composite spring, the two halves may be unwound as desired in order to increase its effective length (*Fig.* 5).

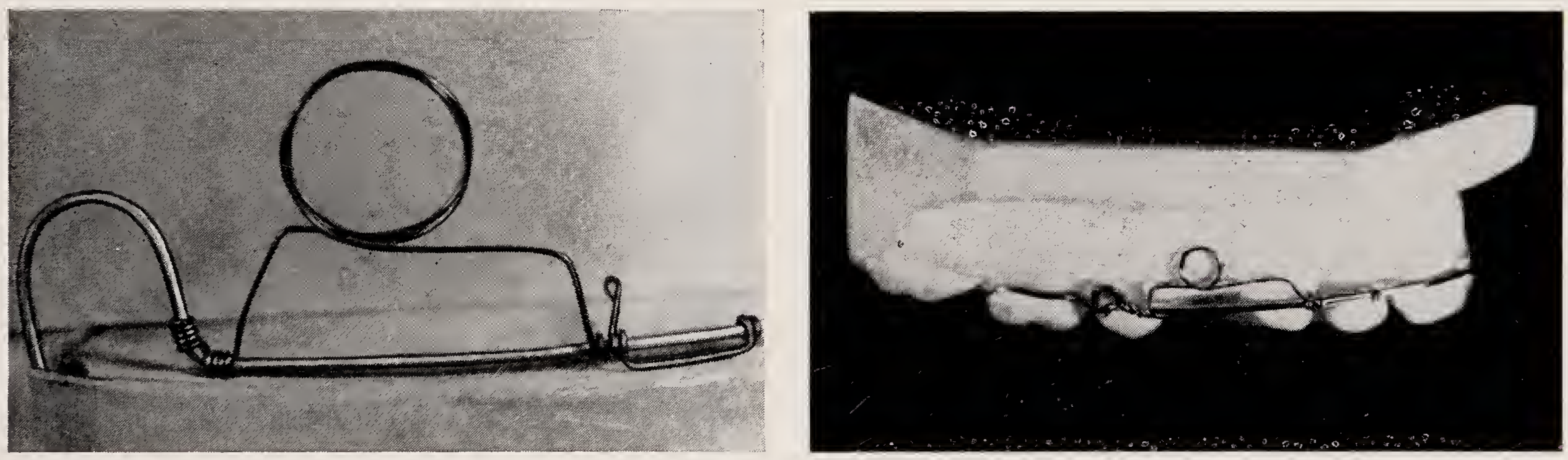
AUXILIARY SPRINGS FOR RETRACTION OF CANINES

By **E. K. BREAKSPEAR,** L.D.S. R.C.S. (Eng.), D.Orth. R.C.S.

THE four springs demonstrated have been fully described elsewhere by Rix (1938) and Breakspear (1949). They are normally made in 0·3-mm. stainless-steel wire, wound on a 0·8-mm. bow. The aim of the series was to produce a spring with a gentle continuous action, but sufficiently resistant to displacing forces in the mouth, capable of easy change or replacement, and requiring no soldering or welding. In each case the first two sets of coils are purely for attachment, the active portion of the spring lying beyond the second set. Working arm and stabilizers slide freely on the main bow. The springs are usually made at the chairside, the patient having first become accustomed to wearing the appliance without them.

A B

Fig. 1.—Canine retraetor No. 1. A, Enlarged model; B, As used in the mouth.



A B

Fig. 2.—Canine retractor No. 2. A, Enlarged model; B, As used in the mouth.

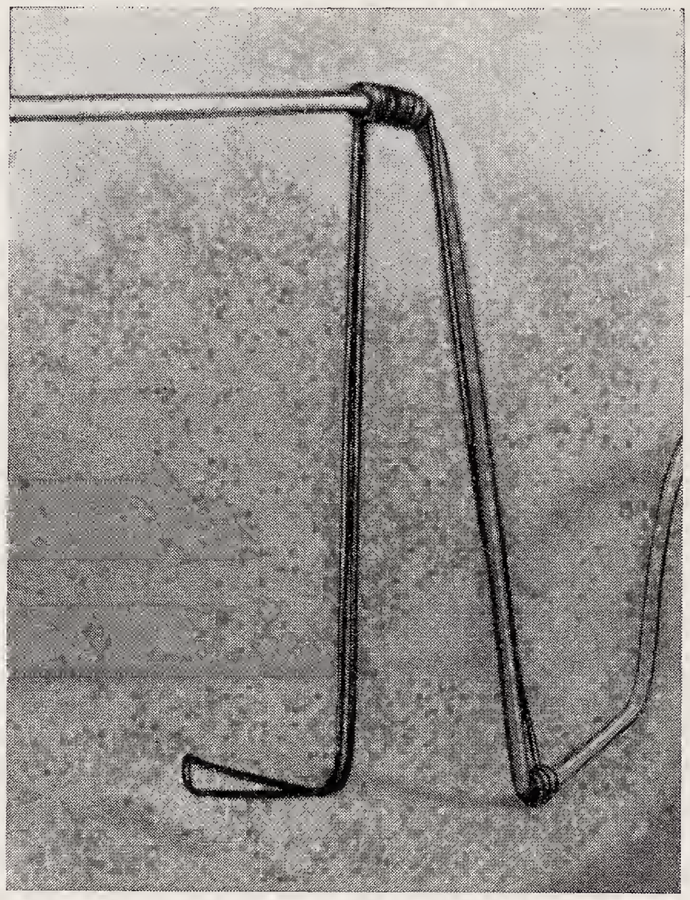
The following points were made in discussion. *Canine retractor No.* 1 (*Figs.* 1 A, B), though effective, suffered from comparative harshness, vulnerability, and a tendency to distort under tension. It is now superseded by *canine retractor No.* 2 (*Fig.* 2 A, B), incorporating a near-vertical element which makes for smoother and more precise action, the coils being smaller and more compact. (*N.B.*: It will be observed that the seating of the active arm on the tooth illustrated is not ideal. This is discussed later.) As a "general purpose" spring it is particularly useful for retraction of first premolars followed by canines, or for cases where the incisor overlap is to be decreased and a labial bow is included in the appliance. The spring can readily be re-activated when necessary by flattening one or more arcs of the main coil.

Its disadvantages are that: (1) Older patients dislike a horizontal labial bow across

A demonstration at the Sheffield meeting held on May 7, 1955.

the incisors; (2) In the case of incompletely erupted canines (as in *Fig.* 2 B) it is difficult to place correctly on the tooth. In such cases it is advantageous to use the high labial bow with the "*golf-club*" *spring* (*Fig.* 3 A, B) which can be set at any desired level, and can be adapted to move the tooth in any direction in the horizontal plane.

The "golf-club" spring is especially indicated in older patients with crowded incisors, where retraction of 3|3 is to be followed by distal movement of 21|12. These movements can often be done simultaneously by adding the required number of additional springs to a suitably modified bow. The disadvantages are that (1) some patients with a low buccal sulcus cannot tolerate the high corner of the bow; (2) the long free arm is either vulnerable (if single) or liable to become suddenly harsh if accidentally displaced (if double).

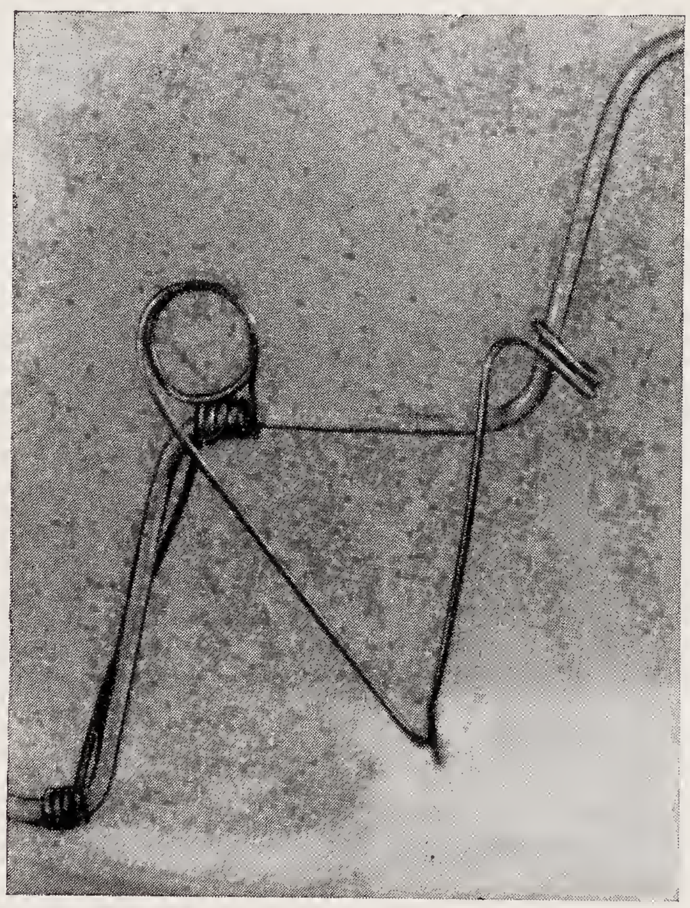


A

B

Fig. 3.—"Golf-club" spring. A, Enlarged model; B, As used in the mouth.

These difficulties are overcome in the *modified canine retractor* (*Fig.* 4 A, B). A step is made in the bow, which allows the circumoral muscles to drop comfortably over the appliance. By virtue of the additional coils, the active portion of the spring resembles a single-arm "golf-club", giving gentleness of action and long range of movement between adjustments. Stability is provided by the compact construction, which reduces the displacing forces, and the oval stabilizing loop, with its supporting arm. It is especially suitable for patients who are away at boarding school.



A

B

Fig. 4.—Modified canine retractor. A, Enlarged model; B, As used in the mouth.

As demonstrated, its locus of movement is a downwards and backwards curve, in itself an undesirable characteristic; when the tooth to be moved is incompletely erupted, however, this mode of action becomes an advantage. (Compare the seating of the working arm with that of canine retractor No. 2 in the same case —*Figs.* 2 B, 4 B). This effect can be overcome either by periodical adjustment to the working arm, or by placing the coil more directly over the arm, producing a pendulum-like movement: this reduces space available for attachment of an apron spring later if required.

Canine retractor No. 1 is now rarely used, but the three others each have an application in everyday practice, some being particularly indicated in certain types of case. Many variations are possible for individual requirements.

I wish to express my thanks to Mr. R. Ernest Rix for permission to demonstrate canine retractors No. 1 and No. 2 and the "golf-club" spring, which are of his devising. Mr. Rix has pointed out that in such a case as shown in *Fig.* 2 B he would keep the horizontal portion of the spring very short, and would obtain horizontal extension by means of a sliding runner carrying the working arm at the far end. He also prefers a single to a double coil, for ease of adjustment. My thanks are also due to Dr. M. C. Manifold for the preparation of the photographs.

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A SURVEY OF MALOCCLUSION AND SOME AETIOLOGICAL FACTORS IN 1000 SHEFFIELD SCHOOLCHILDREN

AN INTERIM REPORT

By **J. H. GARDINER,** B.D.S. (Manch.), D. Orth., R.C.S. (Eng.)
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One way in which our knowledge of malocclusion and its causes is being extended is by the examination of different samples of children. Edward Angle, in 1899, published a table of 1000 cases of malocclusion classified according to the mediodistal relationship of their dental arches. Since then several surveys have been published of varying numbers of American (Goldstein and Stanton, 1936; McCall, 1944), German (Korkhaus, 1928), Australian (Taylor, 1935), Norwegian (Telle, 1951), English (Sclare, 1945; Humphreys and Leighton, 1950), and Irish (Dockrell, Clinch, and Scott, 1955) children. Each of these surveys makes its own contribution to our knowledge of the incidence and nature of malocclusion.

In my own investigations, I have considered malocclusion to be any departure from normal occlusion, which is, in my opinion, severe enough to warrant orthodontic treatment, and I have taken as exhibiting a good normal occlusion any dentition which has good arch form and all teeth in good relation to adjacent as well as to opposing teeth.

Whilst in Sheffield I have had the opportunity of exploring the following points:—

1. The incidence of the different classes of malocclusion in such a city.
2. The incidence of some of the more common known causes of malocclusion.
3. The incidence of those malocclusions which in my opinion require treatment.

A "pilot" survey was commenced on 500 children in 1950 to ascertain the incidence of the different classes of malocclusion only. This first "pilot" survey proved to be inadequate, so in the second trial survey, begun two years later, a more detailed examination was made of the occlusion and some of the causes of malocclusion were included. About that time the late Miss K. C. Smyth was conducting a similar survey on Middlesex schoolchildren. We accordingly joined forces, established a list of points to be investigated, and also standardized a technique of examination. A 'key' of these points was prepared and slips printed on which the information could be recorded in code at the time of examination, and later transferred to punched cards for ease of sorting. In January, 1953, then, the present survey of 1000 children was commenced.

The school in which this survey was carried out is a county school situated between the city and suburban areas of Sheffield, which has a total population of over 512,000 and a school age population (i.e., 5–15 years) of 75,000. This school includes Boys', Girls', and Infants' Departments teaching children between 5 and 15 years of age and has over 1000 pupils, 6 per cent being from professional, 64 per cent from artisan, and 9 per cent from labouring families. Physically handicapped or mentally retarded children do not attend this school, as special schools are provided elsewhere.

The children examined were from parents who had, for the most part, been in that area of Sheffield all their lives. About 15 per cent of the children had recently moved in from other parts of Britain, but apart from five European families and one Asian family, all were British families.

The examination of the children was carried out in the school premises by the same observer throughout and the information recorded at the time by a clerical assistant. The height and weight of each child and records of any relevant illnesses were taken from the children's school medical cards. The

Given at the meeting held on October 10, 1955.

dental history (especially the history of extractions) was obtained from the child and checked where possible against the school clinic dental cards.

The information given by the children about their own habits such as thumb-sucking was found to be unreliable, but the teachers gave quite reliable information about children who

Fig. 1.—Measuring space loss.

indulged in these habits at school. In addition a circular was sent to each parent requesting the previous history of these habits. The appearance of the skin of the digit was also examined for evidence of sucking, and only those cases with a definite history of sucking habits were finally recorded.

The clinical examination of each child consisted of:—

1. Examination of the dentition.
2. Examination of the soft tissues.
3. Examination of the occlusion.
4. Investigation of habits.
5. Assessment of treatment required.

1. Examination of the Dentition.—

a. Teeth erupted, the stage of eruption, and if deciduous whether firm or loose.

b. Teeth unerupted *c.* Teeth absent *d.* Extra teeth	X-rays being taken where necessary.

e. Gross caries.

f. Oral hygiene.

g. Teeth of abnormal size or shape.

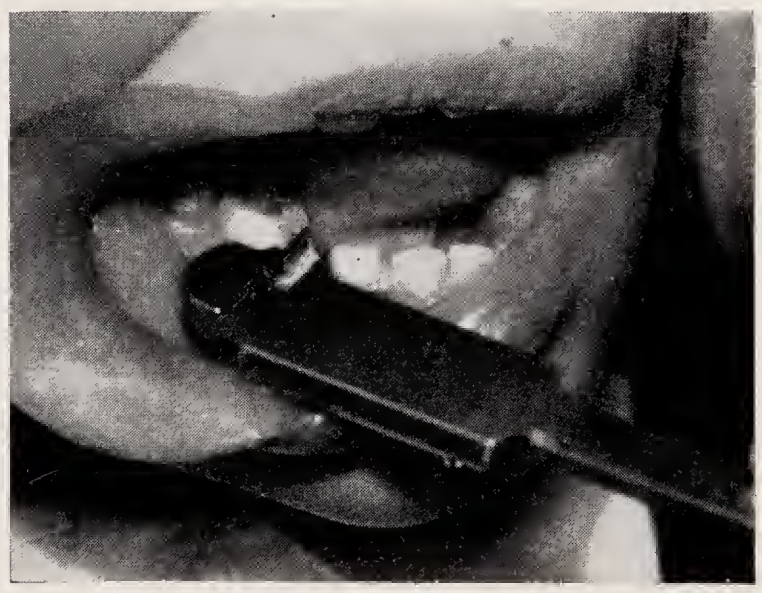
h. Fractured teeth.

i. Inclined and misplaced teeth.

j. Spacing of teeth and median diastemata.

k. Crowding of teeth.

l. Drifting of teeth due to the premature loss of neighbouring teeth. (Where drifting had occurred owing to the loss of a neighbouring tooth, a similar tooth, if present on the other side of that arch, was measured across its mediodistal width and this compared with the reduced space of the affected side (*Fig.* 1); this reduced space being measured with the



specially made internal callipers shown in *Fig.* 2.)

2. Examination of the Soft Tissues.—

a. Lips (whether or not habitually apart and whether or not the lower lip lay habitually lingual to the upper incisors).

b. Labial fræna (whether or not blanching was produced in the palate when the frænum was stretched).

c. Tongue (whether or not thrust forward on swallowing).

d. Thumb and fingers (whether or not the skin on dorsal surface hardened, or the palmar surface wrinkled or the digit twisted).

3. Examination of the Occlusion.—

a. Anteroposterior: according to Angle's classification. Malrelation between the lower

arch and the upper arch (having first allowed for arch development (Friel, 1954) and the local drifting of teeth following premature extraction) *by more than half the mediodistal width of a cusp.*

b. Faciolingual: to determine whether or not any tooth or teeth were in a cross-bite or linguocclusion.

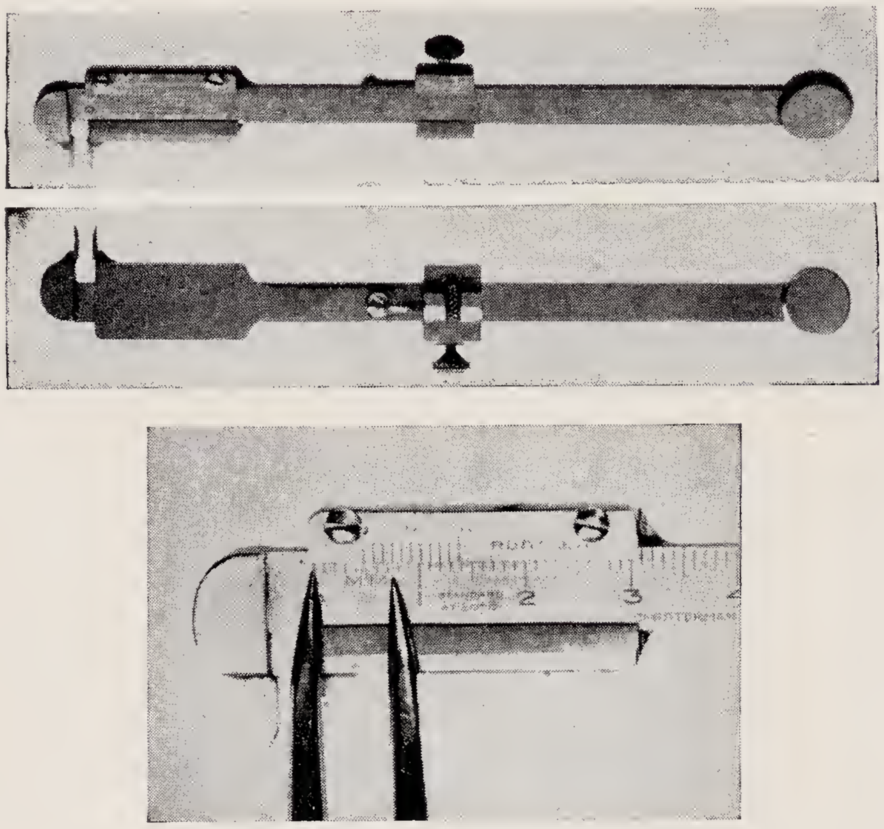


Fig. 2.—Special callipers used.

c. Vertical: to establish whether the bite was open, normal, or closed in the incisor region.

4. Investigation of Habits.—

a. Thumb or finger sucking.

b. Lip (whether held passively or actively in a malposition).

c. Tongue (whether held passively or actively in a malposition).

d. Nail-biting.

5. Assessment of Treatment required.—

a. Its urgency.

b. Whether observation only or active treatment was required; and if so

c. Whether it could be carried out by an assistant or whether a trained orthodontist was required; or

d. Whether the patient, owing to lack of reasonable interest, extreme caries, or gingivitis, was unsuited to receive orthodontic treatment.

OBSERVATIONS

A brief summary of the results is:—

1·6 per cent of the children were found to have congenital absence of one or more teeth and a few cases (0·5 per cent) had clinical evidence of supernumerary teeth but, as full mouth radiography on a large scale was not possible, the complete incidence was not known. Using radiographs Dolder (1936) found that in 10,000 Swiss schoolchildren, the incidence of missing teeth was 3·4 per cent. In addition he found that the incidence of supernumerary teeth was 0·3 per cent, which agrees with Macphee's (1935) findings on the erupted supernumerary teeth in 4000 Glasgow schoolchildren.

11·4 per cent of the children had overcrowded dental arches due, in my opinion, to the teeth being too large for the available basal bone. These were assessed visually and were not measured, so any doubtful cases were not included in this total. 1 per cent of the children had individual teeth which were too large, e.g., upper lateral incisors which were of a similar width to the upper central incisors.

1·1 per cent of the children had deciduous molars in infra-clusion.

6 of the children had lower 1st deciduous molars affected in this way.

2 of the children had lower 2nd deciduous molars affected in this way.

Table I.—Age Distribution of Median Diastema (Total 277 in 1000)

	6 yr.		7 yr.		8 yr.		9 yr.		10 yr.		11 yr.		12 yr.		13 yr.		14 yr.		15 yr.	
	B.	G.	B.	G.	B.	G.	B.	G.	B.	G.	B.	G.	B.	G.	B.	G.	B.	G.	B.	G.
Up to 1·9 mm.	16	15	27	26	25	22	14	19	5	2	5	6	9	9	3	11	10	8	—	2
2·0–2·9 mm.	3	2	10	8	3	4	4	1	—	—	—	—	—	—	1	—	1	0	—	—
3 mm. and over	2	2	—	1	—	1	—	—	—	—	1	—	—	—	—	—	—	1	—	—
Total/year total	40/87		72/147		55/128		38/115		7/70		11/98		19/98		15/128		20/101		2/28	
Percentage	46		48		43		33		10		11		19		12		20		7	

1 of the children had upper 1st deciduous molars affected in this way.

1 of the children had all four 2nd deciduous molars affected in this way.

1 of the children had all four lower deciduous molars affected in this way.

2 per cent had lost between one quarter and one half of the original spacc;

44 per cent had lost over onc half of the original space, but more follow-up observations have to be made on these 190 children along the lines of Pringle (1937, 1938), Schachter

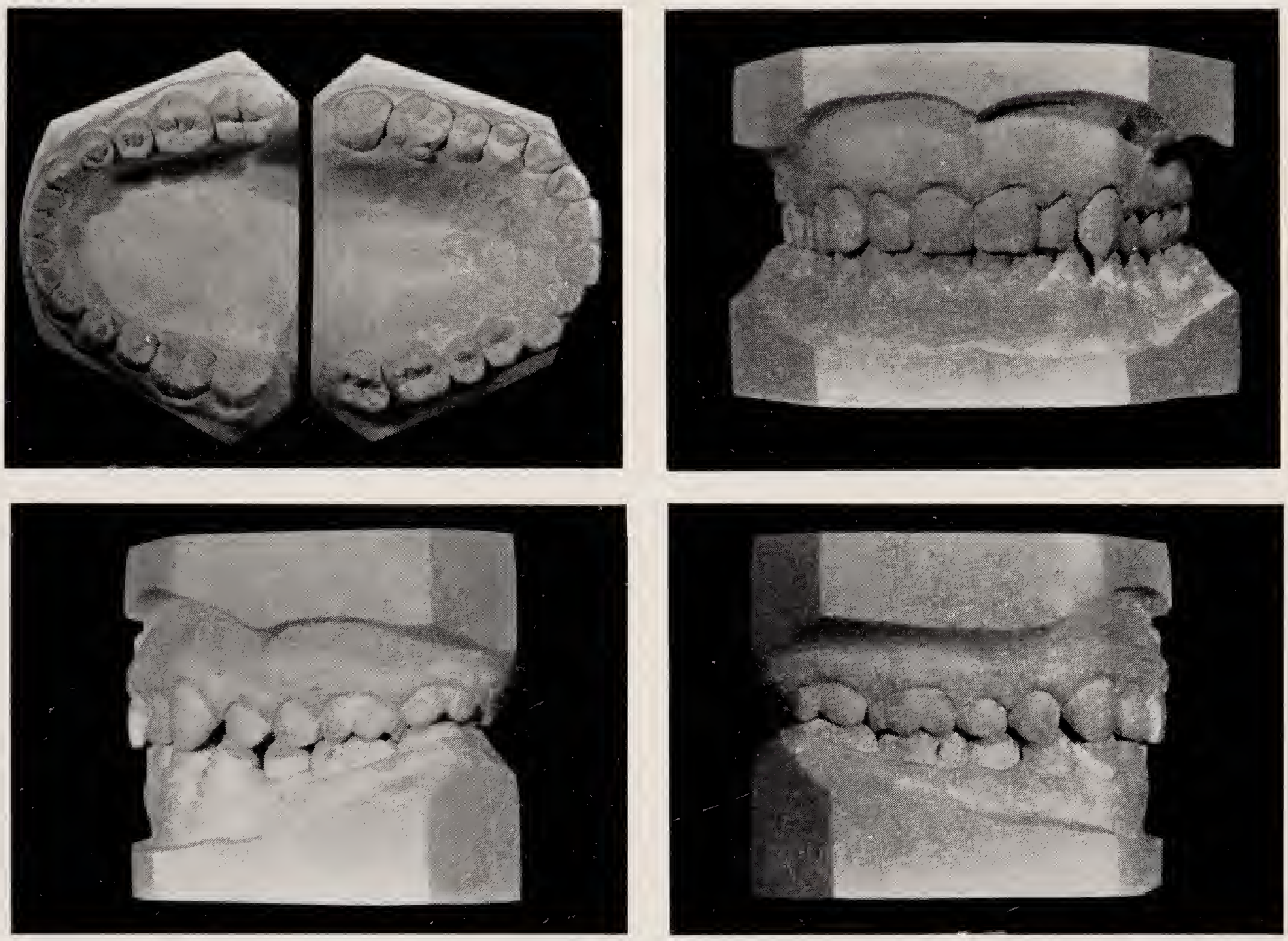


Fig. 3.—An example of one of the best occlusions examined.

(1943), Seipel (1949), and Breakspear (1951) before any useful information can be obtained.

In a further 41 per cent of the children space loss had occurred, but because of the absence of, or severe interproximal caries in, the corresponding tooth on the opposite side of the dental arch, it was not possible to measure the space lost. The remaining 40 per cent of the children had not suffered any space loss due either to their dental arches being intact or to the deciduous molar having been lost only just prior to the examination.

As stated previously, in the present survey "malocclusion" has been taken to mean any departure from normal occlusion which is, in my opinion, severe enough to warrant treatment, and normal occlusion has been accepted as being in a dentition where there is good

A space between the upper central incisors occurred in 27·7 per cent of the cases and the age distribution shows the condition to decrease with age; as shown in *Table I*. 229, or over 80 per cent, of these cases with a median diastema were associated with persistent fræna.

Regarding loss of space in the dental arches due to premature loss of the deciduous molars or loss of tooth width due to caries, in 19 per cent of the children it was possible to measure the space lost by comparing the reduced space on the site of the extraction with the mediodistal width of a sound tooth on the opposite side of the dental arch as shown previously.

The immediatc results from these 19 per cent are:—

34 per cent lost up to a quarter of the original space;

arch form and all teeth in good relation to adjacent as well as to opposing teeth. An excellent form of such an occlusion is seen in *Fig.* 3 and a similar standard of dentition occurred in 2·1 per cent of all the 1000 children examined. Another 23·7 per cent of all the children, though not possessing an excellent occlusion, would develop a good working occlusion without the aid of orthodontic treatment. It is natural that the definition of normal occlusion will vary with each observer, and from a review of other surveys (Korkhaus, 1928; Goldstein and Stanton, 1936; and Telle, 1951) my own definition would appear narrow.

In the present survey, then, 74·2 per cent of the children were considered to have some form of malocclusion and this was considered under three headings:—

1. Anteroposterior malrelations of the dental arches.
2. Vertical malrelations of the dental arches, i.e., open or close bite.
3. Lateral malrelations of the dental arches i.e., cross-bite conditions.

So that they could be compared with other surveys the anteroposterior arch malrelationships were classified under Angle's system, i.e., whether the lower arch lay *more than ½ cusp unit medial or distal to the upper arch*, as shown in *Fig.* 4. The importance of defining these limits of occlusal malrelationship was shown by the fact that *if all the children having exactly ½ cusp unit distocclusion were included in Class II the result would be* 25 *per cent instead of the* 10·9 *per cent shown in Table II.*

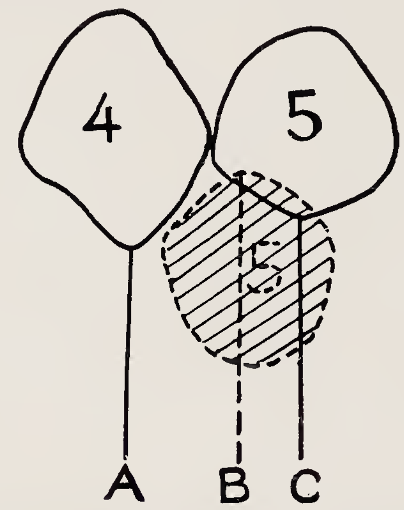


Fig. 4.—Diagram showing the extent of distal and medial occlusion designated as Class II and III.

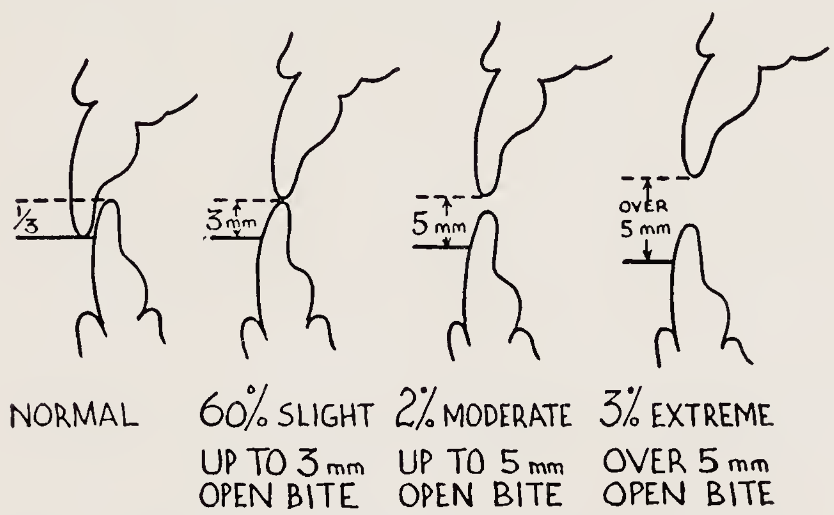


Fig. 5.—Diagram showing the measurement of open bite in those occlusions with little or no overjet.

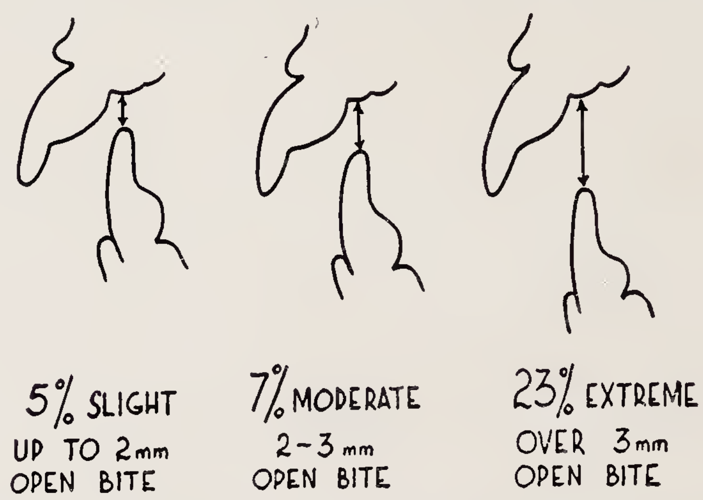


Fig. 6.—Measurement of open bite where a marked overjet was present.

Table II.—Incidence of Malocclusion (Angle)

Angle Class I	88·5 per cent
Angle Class II	10·9 per cent
Angle Class III	0·6 per cent

Angle Class II		*Angle Class III*
73 per cent Unilateral	37 per cent division (1)	66 ⅔ per cent Bilateral
27 per cent Bilateral	10 per cent division (2)	33 ⅓ per cent Unilateral
	53 per cent neither	
18 per cent Open bite		33⅓ per cent Open bite
82 per cent Close bite		66⅔ per cent Close bite

Considering now the malrelations in a *vertical plane*, 14·8 per cent of the children had an open bite. This was measured as shown in *Fig.* 5. Where the incisal edges were in the same vertical plane, the degree of open bite was measured in millimetres from the tip of the upper central incisors down to the point

of normal overbite, which was taken to be one third the crown height of the lower incisors. These cases were divided into three groups (*Fig.* 5): in the first group were those cases with a diminished overbite up to an

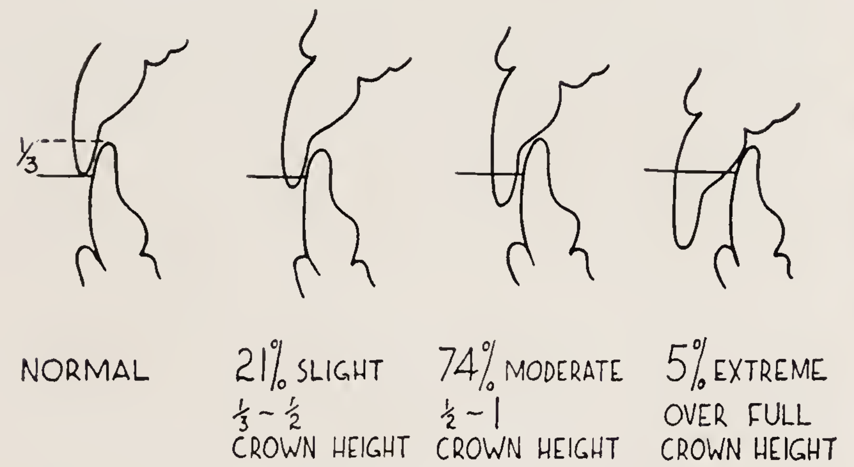


Fig. 7.—Measurement of overbite.

edge-to-edge incisor bite. In the second group were those having an actual vertical space between the incisal edges of up to 2 mm. The third group consisted of those with a vertical space of over 2 mm. In cases of severe overjet, e.g., Angle Class II (1), the overlapped the lower central incisors. A third of the lower crown height overlap was regarded as normal (*Fig.* 7).

Fig. 8.—Testing a prominent frænum for any attachment to the palatal tissues.

The age distribution of both open bite and overbite is shown in *Table III.*

Table III.—Age Distribution of Open and Close Bite

Age Distribution of Open Bite

	6 yr. B. G.	7 yr. B. G.	8 yr. B. G.	9 yr. B. G.	10 yr. B. G.	11 yr. B. G.	12 yr. B. G.	13 yr. B. G.	14 yr. B. G.	15 yr. B. G.
Slight	6 6	11 10	5 8	2 3	2 3	1 6	1 2	5 7	4 10	2 2
Moderate	1 1	1 2	— —	1 2	1 —	— —	1 2	— 1	1 1	— —
Extreme	3 3	4 7	— 4	— 1	1 —	3 1	2 1	2 3	1 1	— —
Total/year total	20/87	35/147	17/128	9/115	7/70	11/98	9/98	18/128	18/101	4/28
Percentage	23	24	13	8	10	11	9	14	18	14

Age Distribution of Close Bite

	6 yr. B. G.	7 yr. B. G.	8 yr. B. G.	9 yr. B. G.	10 yr. B. G.	11 yr. B. G.	12 yr. B. G.	13 yr. B. G.	14 yr. B. G.	15 yr. B. G.
Slight	8 7	8 14	15 6	7 11	6 6	7 8	11 13	10 20	11 15	1 4
Moderate	28 13	35 29	46 36	43 39	27 17	33 34	34 29	29 42	25 24	3 13
Extreme	2 1	5 3	3 —	4 —	2 2	3 —	— —	4 2	5 1	— 1
Total/year total	59/87	94/147	106/115	104/115	60/70	85/98	87/98	107/128	81/101	22/28
Percentage	68·8	63·8	82·8	90	86	86·7	88·7	84·3	81	78·5

lower incisors lay below the palatal tissues (*Fig.* 6). In these cases the degree of open bite was measured in millimetres from the point of normal overbite to the palatal tissues directly above that point.

Overbite was measured according to the extent that the upper central incisors

Lateral malrelations or posterior cross-bite of the dental arches occurred in 9·5 per cent of the children.

Examination of the soft tissues revealed:—

47·6 per cent of the children had a persistent upper labial frænum. This was tested by stretching (*Fig.* 8).

27·2 per cent of the children had sucked thumbs or fingers, and of these 64, or 24 per cent, were still actively sucking at the time of the examination, but only a small proportion

Table IV.—Age Incidence of Open Mouth Habit

	6 yr. B. G.	7 yr. B. G.	8 yr. B. G.	9 yr. B. G.	10 yr. B. G.	11 yr. B. G.	12 yr. B. G.	13 yr. B. G.	14 yr. B. G.	15 yr. B. G.
	18 5	29 24	21 10	19 21	15 8	24 9	19 14	14 17	22 10	2 5
Total/year total	23/87	53/147	31/128	40/115	23/70	33/98	33/98	31/128	32/101	7/28
Percentage	26·4	36	24·2	34·8	32·9	33·7	33·7	24·2	31·7	25

(39 out of 272, or 14 per cent) had succeeded in producing a malocclusion, e.g., unilateral incisor open bite or unilateral overjet or retroclined lower incisors with proclined upper incisors, which could be directly attributed to these habits.

Table V.—A Comparison of the Malocclusions in Children with and without an Open Mouth Habit

	Out of 306 *Children with Open Mouth Habit*	*Out of* 306 *Children without Open Mouth Habit*
Crowded upper incisors	88	78
Crowded lower incisors	87	55
Proclined upper incisors	75	37
Proclined lower incisors	52	30
Close bite	224	255
Open bite	71	37
Posterior cross-bite	46	55

30·6 per cent of the children had an open mouth habit (*Fig.* 9) and this varied as the age increased (*Table IV*). Of these, 140, or 45 per cent, had difficulty in breathing through their

Table VII.—Age Incidence of Tongue Habits (Anterior Only)

	6 yr. B. G.	7 yr. B. G.	8 yr. B. G.	9 yr. B. G.	10 yr. B. G.	11 yr. B. G.	12 yr. B. G.	13 yr. B. G.	14 yr. B. G.	15 yr. B. G.
	5 7	11 16	4 11	1 2	1 2	4 7	3 5	5 10	2 4	— 2
Total/year total	12/87	27/147	15/128	3/115	3/70	11/98	8/98	15/128	6/101	2/28
Percentage	14	18	12	3	4	12	8	12	6	7

nose and many had the small nostrils seen in *Fig.* 9. The common malocclusions in these children with an open mouth habit are shown in *Table V.*

6·6 per cent of the children held the lower lip under the upper incisors, and many of these cases had prominent upper incisors often with spacing (*Table VI*). In 41 per cent of these cases it was a posture, the lip remaining there passively, but in 59 per cent of these cases it was an active habit. The age distribution of these lower lip habits shows no great increases or decreases with age.

Examination of the tongue showed:—

0·6 per cent of the children held the tongue passively between the occlusal surfaces of the posterior teeth.

Table VI.—Malocclusions associated with Lower Lip Habit

	No. in 1000	*Prominence of Upper Incisors*	*and/or*	*Spacing of Upper Incisors*
Those having lower lip lying passively under upper incisors	27	15		8
Those having active lower lip habit	41	25		18

10·2 per cent thrust the tongue forwards on swallowing in the manner described by Rix (1946). 53 per cent of these had an open anterior bite.

2·6 per cent thrust the tongue laterally on swallowing.

5·2 per cent of all the children had, in addition to the tongue-thrusting habit, a thumb- or finger-sucking habit. The age incidence of these tongue habits is shown in *Table VII.*

Nail-biting occurred in 22·9 per cent of the children (*Fig.* 10) and the age distribution (*Table VIII*) shows that the habit reduces with age but no malocclusion in the children examined could be attributed to this factor as far as could be ascertained (*Table IX*).

Fig. 9.—Open mouth habit.

Also included in this survey were the two subsidiary points of eruption dates and oral hygiene.

The state of oral hygiene in the children varied and they were divided into three groups according to the cleanliness of their mouths. In the first group of 36 per cent were those children with clean mouths. The second group of 48 per cent consisted of those children with a visible mucous film over their teeth. The remaining 16 per cent were in the third group who rarely if at all brushed their teeth, so that food debris was visible in the gingival sulcus in addition to stain and coating on the teeth.

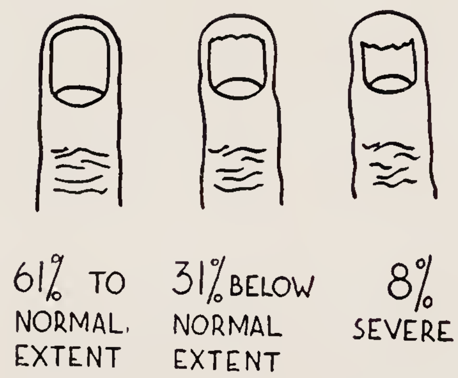


Fig. 10.—Classification of nail-biting.

Treatment is a matter of individual opinion and so rather a difficult thing to assess. What one orthodontist would treat another may not. The following estimations err on the side of too much rather than too little treatment, for not only was it assumed that the maximum facilities were available for treatment but also that, unless otherwise clearly indicated, the child and the parents would accept the necessary orthodontic treatment. Therefore this is an estimate of the treatment *required* rather than the treatment *demanded.*

Table VIII.—Age Incidence of Nail-biting

	6 yr.		7 yr.		8 yr.		9 yr.		10 yr.		11 yr.		12 yr.		13 yr.		14 yr.		15 yr.	
	B.	G.	B.	G.	B.	G.	B.	G.	B.	G.	B.	G.	B.	G.	B.	G.	B.	G.	B.	G.
Normal extent	1	2	11	9	13	6	7	8	4	7	12	7	13	5	8	9	4	13	—	2
Below normal	4	1	4	3	1	3	2	3	1	3	6	4	5	9	4	6	7	3	—	1
Severe	—	—	—	—	2	2	—	—	—	—	2	2	1	1	1	2	1	2	—	2
Total/year total	8/87		27/147		27/128		20/115		15/70		33/98		34/98		30/128		30/101		5/28	
Percentage	9·2		18·4		21·1		17·4		21·4		33·7		34·6		23·4		29·7		17·8	

Examination of the dentition of these children showed that the eruption dates of some of their teeth varied from those of the 1792 Birmingham children in the survey by Clements, Davies-Thomas, and Pickett (1953) and from the survey of children by Ainsworth (1925) as shown in *Table X*.

3·4 per cent of all the children were found to be unsuitable for treatment owing to lack of availability (leaving school or the district), very poor oral hygiene, or a lack of reasonable interest in the treatment.

2·1 per cent of all the children had excellent occlusions, so would not require any orthodontic treatment.

23·7 per cent of all the children, though not possessing an ideal occlusion, would, in my opinion, develop a good working occlusion without the aid of orthodontic treatment.

Table IX.—Malocclusions in those Children biting their Nails

Extent of Nail-biting	No.	Lingual Occlusion of Incisors	Edge-to-edge Bite of Incisors	Incisal Open Bite	Close Bite	Crowded Upper Incisors	Proclined Upper Incisors	Retroclined Upper Incisors	Class I	Class II	Class III	Digit Sucking Habits
Trimming to normal extent	141	12	5	12	120	43	28	7	85	49	6	33
Trimming below normal	70	7	3	9	35	20	14	3	49	25	—	26
Severe	18	3	—	1	11	6	4	1	14	4	—	4

20·4 per cent of all the children were doubtful cases which, though not requiring active treatment at the time of the examination, were recommended to be inspected periodically to ascertain whether their malocclusion was progressing in undesirable directions.

Table X.—Ages of Tooth Eruption

	Year	No. of Children	$\overline{1\|1}$	$\overline{6\|6}$	$\underline{6\ 6}$	$\underline{1\ 1}$	$\overline{2\|2}$	$\underline{2\|2}$	$\underline{4\ 4}$	$\overline{3\|3}$	$\overline{4\|4}$	$\underline{5\|5}$	$\underline{3\|3}$	$\overline{5\|5}$	$\overline{7\|7}$	$\underline{7\|7}$
Sheffield Survey	1953–54	1000	6	6	6	7	7	$7\frac{1}{2}$	9	$9\frac{1}{2}$	$9\frac{1}{2}$	10	11	$11\frac{1}{2}$	$11\frac{1}{2}$	$11\frac{1}{2}$
Clements, Davis-Thomas, and Pickett	1947–48	1792	6	6	6	$6\frac{3}{4}$	7	$8\frac{1}{2}$	10	10	11	$11\frac{1}{4}$	11	12	$11\frac{1}{4}$	$11\frac{3}{4}$
Ainsworth	1924	4258	$6\frac{1}{2}$	6	6	7	$7\frac{1}{2}$	$8\frac{1}{2}$	10	$10\frac{1}{2}$	$10\frac{1}{2}$	11	$11\frac{1}{2}$	$11\frac{1}{2}$	$11\frac{1}{2}$	12

39·8 per cent of all the children were cases requiring uncomplicated treatment, e.g., extractions and/or simple orthodontic appliances such as an oral screen, inclined plane, screw or finger spring plates.

10·6 per cent of all the children were complicated cases involving treatment by an experienced orthodontist with fixed and/or the more advanced myofunctional appliances.

DISCUSSION

In considering these results the question of whether there is some connexion between a midline diastema and a prominent frænum might be considered more fully.

When first examining fræna, it was realized that there were two main types, i.e., those which, when stretched, produced blanching in the anterior tissues of the palate (*Fig.* 8) and those which did not produce blanching, the ratio being approximately 4:1. In order to study further the more numerous blanching type of frænum, it was decided to divide them into four sizes, as shown in *Fig.* 11.

Table XI.—The Relation between Frænum and Diastema

Frænum	Diastema: Nil	Diastema: Under 1·9 mm.	Diastema: 2·0–2·9 mm.	Diastema: Over 3 mm.
88 Non-blanching	72	12	3	1
153 Small	70	74	8	1
166 Medium	70	81	13	2
58 Large	13	32	9	2
11 Extra large	—	5	3	4

In *Table XI* can be seen the relation between the different types of frænum and the width

in millimetres of the median diastema associated with them. Broadly, the larger the frænum the wider the diastema, but this does not explain whether the frænum causes the diastema or the diastema permits the frænum to persist. Tait (1924) states that "the frænum is an effect sometimes associated with, but not the cause of, separated upper central incisors". Taylor (1939) says that "The space may be the result of a number of causes among which are tongue, finger, or lip habit, endocrine dysfunction, missing teeth, short upper lip, anterior dental protraction, peg laterals, large mandibular teeth". *Table XII*, therefore, shows the correlation between some of these different factors and the width of the diastema. As can be seen, the most constant factor in these median diastema cases would seem to be a persistent frænum, and most observers (Tait, 1924; Taylor, 1939) are agreed that the incidence of fræna decreases with age (*Table XIII*).

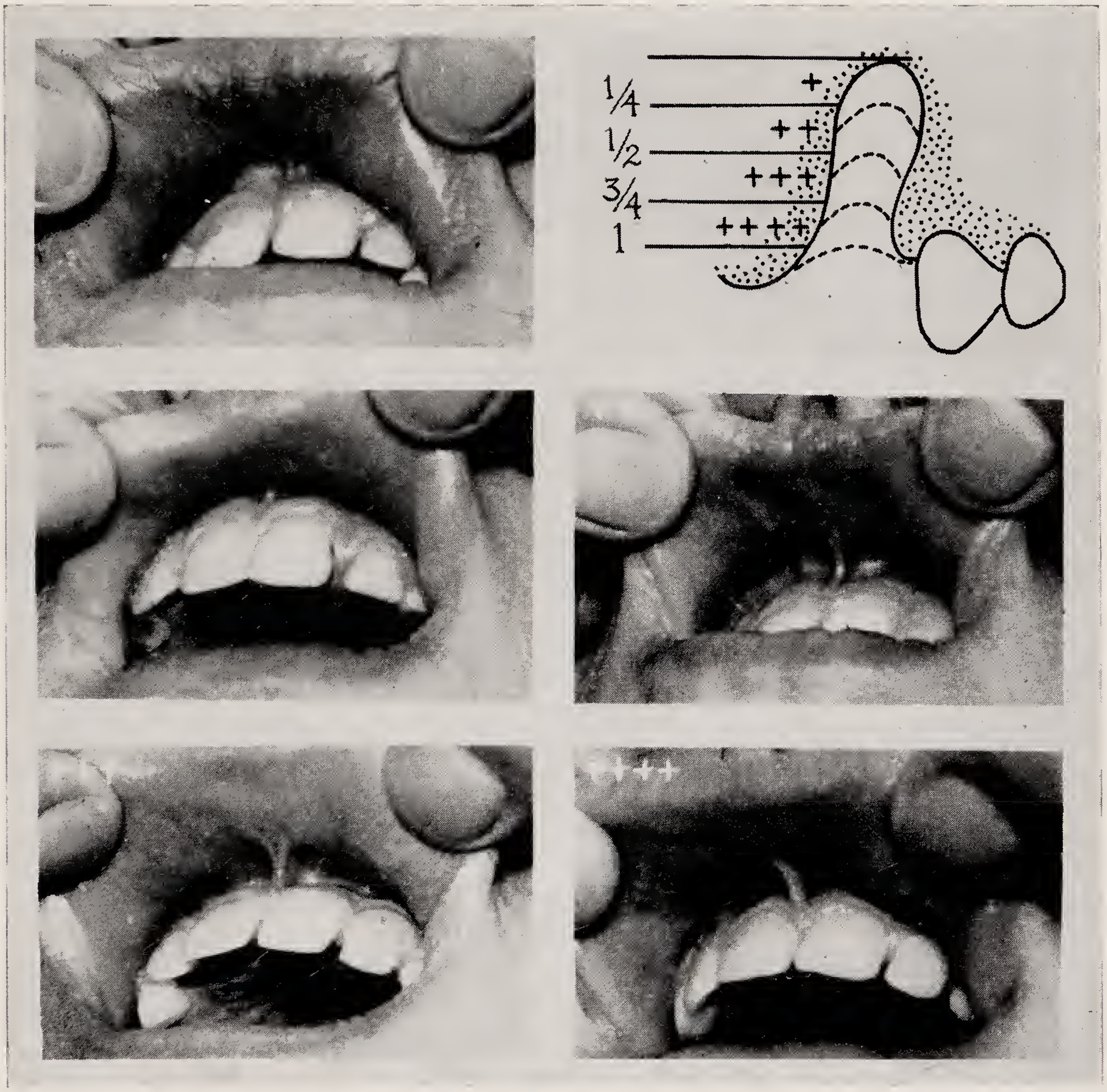


Fig. 11.—Sizes of the frænæ that produced, when stretched, blanching of the palatal tissues.

The question of open incisor bite is obviously quite extensive. In this survey it was not possible to investigate all the causes, such as heredity, but it was possible to show the different conditions which accompanied such a malocclusion (*Table XIV*). Seipel (1949) also found that the incidence of open incisor bite decreased with age, and Goldstein and Stanton (1936) attribute this to the reduction in sucking habits. Humphreys and Leighton (1950) in their survey found that almost all cases with an open bite were associated with sucking

habits and the findings of Ruttle, Quigley, Crouch, and Ewan (1953) were similar.

The final question that I wish to consider is the incidence and the effect of the various sucking habits (*Table XV*). The significant points arising from these results would seem to be:—

1. Only 14 per cent of the children who had sucked or were sucking fingers or thumbs had a malocclusion which could be attributed to it.

2. Only half the children actively sucking fingers or thumbs at the time of examination showed evidence of this on their digits.

3. Dummy sucking habits had the advantage of not extending beyond 4 or 5 years of age.

4. Only 3 per cent of the children who had dummies subsequently developed thumb

Table XII.—CONDITIONS ASSOCIATED WITH A MEDIAN DIASTEMA

	WIDTH OF MEDIAN DIASTEMA		
	Up to 1·9 mm.	2·0 to 2·9 mm.	Over 3·0 mm.
No. having median diastema as shown	233	38	9
No. having crowded upper incisors	18	2	—
No. having spaced upper incisors	94	12	3
No. having prominent upper incisors	46	5	2
No. sucking thumbs or fingers at time of examination	19	1	2
No. having lower lip habit	23	3	1
No. thrusting tongue forwards	26	11	2
No. having open mouth habit	75	13	1
No. having a frænum	202	38	8
No. having absence of $\underline{2|2}$	3	—	—
No. having small $\underline{2|2}$	—	—	—

Table XIII.—AGE DISTRIBUTION OF LABIAL FRÆNUM (TOTAL 476 IN 1000)

	6 yr. B.	6 yr. G.	7 yr. B.	7 yr. G.	8 yr. B.	8 yr. G.	9 yr. B.	9 yr. G.	10 yr. B.	10 yr. G.	11 yr. B.	11 yr. G.	12 yr. B.	12 yr. G.	13 yr. B.	13 yr. G.	14 yr. B.	14 yr. G.	15 yr. B.	15 yr. G.
Non-blanching	9	4	7	12	—	1	3	4	2	—	5	1	5	3	13	4	11	2	1	1
Small +	11	4	15	14	26	9	12	12	3	3	4	5	4	8	4	10	2	7	—	—
Med. ++	12	10	23	23	10	18	8	10	4	5	4	5	7	7	3	7	6	3	—	—
Large +++	9	9	7	8	4	6	3	3	1	—	1	—	—	3	1	1	1	—	—	1
V. Large ++++	3	3	—	1	—	1	1	—	—	—	—	—	—	—	—	1	1	—	—	—
	44	30	52	58	40	35	27	29	10	8	14	11	16	21	21	23	21	12	1	3
Total/year total	74/87		110/147		75/128		56/115		18/70		25/98		37/98		44/128		33/101		4/28	
Percentage	85		75		59		50		26		25		37		34		33		14	

Table XIV.—OPEN INCISOR BITE (148 in 1000) AND ASSOCIATED CONDITIONS

	Open Bite	*Close Bite*
Open mouth habit	71/306 (23 per cent)	200/306 (65 per cent)
Lower lip habit	9/66 (14 per cent)	55/66 (85 per cent)
Tongue habit (ant.)	68/102 (69 per cent)	27/102 (27 per cent)
Thumb sueking (active)	19/37 (51 per cent)	13/37 (35 per cent)
Finger sucking (active)	8/16 (50 per cent)	5/16 (31 per cent)

or finger sucking habits. Humphreys and Leighton (1950) also came to the conclusion that dummies, although producing some malocclusion, are not as harmful as thumb- or finger-sucking.

Table XV. Sucking Habits

16 per cent of all the children had a history of sucking thumb or fingers up to 5 years 11·2 per cent of all the children had a history of sucking thumb or fingers after 5 years and in 64 of these 112 children the habit was still active at the time of the examination.	Only 39 of these 272 children *or 14 per cent with sucking habits showed a malocclusion* (i.e., unilateral open incisor bite or unilateral overjet) *directly attributable to these habits.*

19·5 per cent of all the children had a history of sucking a comforter. *Only 7 of these 195 children subsequently developed finger or thumb sucking habits.*

2·4 per cent of all the children had a history of sucking other objects (bedclothes, dolls, etc.).

20·6 per cent of all the children had an uncertain history of sucking habits (e.g., orphaned and adopted children).

30·3 per cent of all children had no history of any sucking habit.

Damage to digits following sucking habit

1·7 per cent wrinkled palmar surface.

0·9 per cent hardened skin over knuckle.

0·3 per cent twisted digit.

SUMMARY

1. An account is given of an examination by an orthodontist, of 1000 unselected Sheffield schoolchildren, boys and girls, between the ages of 6 and 15 years.

2. The examination was visual, models and radiographs not being used.

3. The incidence of supernumerary teeth, partial anodontia, large teeth, median diastema, and space loss is given.

4. 742 of the children were considered to have a malocclusion and the arch malrelationships of these, classified under Angle's system, were: 88·5 per cent Class I, 10·9 per cent Class II, and 0·6 per cent Class III. The incidence of open and close bite and posterior cross-bite is also given.

5. The incidence of persistent fræna, lip and tongue habits, finger-, thumb-, and dummy-sucking habits, and nail-biting is shown, together with the effect on the occlusion.

6. The extent and nature of the orthodontic treatment considered necessary is also given.

Acknowledgements.—In conclusion, I would like to acknowledge with gratitude the help I have received from the late Miss K. C. Smyth in planning this survey; from colleagues in the preparation of this paper; from Mr. Cousins, of the United Sheffield Hospitals Department of Medical Photography, in preparing the illustrations; from the University of Sheffield Research Fund; and from the Principal School Medical Officer of Sheffield and the Head Teachers and Staff of the Hunter's Bar School for information and ready help in the examination of these children.

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DISCUSSION

Miss L. M. Clinch, in opening the discussion, said she preferred not to use the term "normal" in describing an occlusion, as it had several different meanings in this connexion.

She thought it would have been an advantage if models had been taken of the children concerned in Mr. Gardiner's investigation, as she felt that a diagnosis of malocclusion could be accurate only if models were examined after the examination of the child. Moreover, models were useful to other people who might want to work on similar material, and they were also valuable in a follow-up of the same material.

Mr. Gardiner stated in his paper that over 80 per cent of the cases in his investigation which had a median diastema were associated with persistent fræna. She thought that all central incisors were associated with a frænum and that it was anatomically correct for these teeth to erupt spaced. Mr. Gardiner showed that the percentage of the children with a median diastema decreased from 46 per cent at 6 years of age to 7 per cent at 15 years of age, but he gave the figure of 47·6 as the percentage of those children with fræna that persisted. When did a frænum become a persistent frænum?

Mr. Gardiner stated that only 14 per cent of the children with sucking habits showed a malocclusion directly attributable to those habits, and he added: "that is unilateral open incisor bite or unilateral overjet". Did he consider that those were the only malocclusions resulting from a sucking habit? She had found many cases of subnormal maxillary arches resulting in a cross-bite and others with linguoclination of the mandibular incisors which she had attributed to sucking habits.

With regard to Mr. Gardiner's statement that many of the children with thumb- or finger-sucking habits showed no evidence of this on their digits, she knew from personal experience that one reason for this was that the tongue could be used as a cushion between the teeth and the thumb or the finger, and that prevented any hardening or thickening of the skin. It was often possible, however, to diagnose a habit from the cleanliness of one digit as compared with the others.

She was surprised that only 0·6 per cent of the children kept the tongue passively between the posterior teeth. She would have thought that, with the jaws in a resting position, the tongue would automatically bulge into whatever space was available. This tied up with the question of tongue thrust and open bite. Would Mr. Gardiner agree that the open bite might come first and that again the tongue would automatically bulge into the open space, at least during swallowing?

On the question of open bite, she had always considered that in a case of anterior open bite there was a vertical space between the tips of the incisors. If the tips of the incisors met she called it an edge-to-edge bite.

When the lateral and central incisors were the same size she had often found that there was not greater tooth bulk but that the total width of the two teeth was about the normal width of a central and a lateral incisor, so a large lateral did not necessarily mean that there must be crowding of the teeth.

It appeared that nail-biting reached its maximum just about the time of the 11+ examination, which was what she would expect.

She would like to ask Mr. Gardiner if he intended to have a statistical analysis made of his figures as this would seem to be a useful line of inquiry in a survey of this kind.

Mr. V. G. Pedley said that the findings in an investigation such as that made by Mr. Gardiner depended to a considerable extent on the type of district in which the children lived. He would be interested to know the social class of the children concerned and whether their environment played any part in the types of malocclusion recorded. He himself treated children in two different types of district; in one the children were of the poorer class and in another they were entirely middle class, and he did not think the same statistics would apply in the two cases.

Mr. B. C. Leighton asked how Mr. Gardiner decided whether the tongue was held actively or passively in malocclusion. This seemed to him to be a rather difficult thing to do.

In the 1·6 per cent of children who apparently had missing teeth, was the deciduous dentition as well as the permanent dentition included and were the third molars included?

It seemed to him that the two methods which Mr. Gardiner used for measuring an open bite were not strictly comparable, because one measurement started from the tip of the upper incisor and the other started from the soft tissues of the palate.

He was surprised at the large percentage of Class II cases (53 per cent) which Mr. Gardiner found could not be put into either division (1) or division (2). He himself had seen such cases, but he had not known that there were so many of them.

He agreed with Miss Clinch's remarks about sucking habits. He had the impression that a cross-bite was a much more common sequel to sucking habits than it would appear to be from what Mr. Gardiner had said. Had he any figures of the incidence of cross-bite among the children who sucked their thumbs?

With regard to the children who thrust their tongues forward when they swallowed, did all of them have their teeth apart at the time of swallowing or did some of them place their teeth into occlusion and thrust the tongue through an existing space between the upper and lower incisors?

The most significant point that he had noticed in the paper was that only 2 per cent of the cases in which space had been lost following early extractions had lost between one-quarter and one-half of the space, all the others having lost either less than one-quarter or more than one-half of the space. It would appear that the children either lost space rapidly and rather completely or did not lose space at all.

Perhaps at some time in the future Mr. Gardiner would be able to give some indication of how many of the 34 per cent in the first group, who had lost less than one-quarter of the space, would not need to have the space maintained.

Mr. G. B. Hopkin said that in his experience there was a familial factor present in most cases of true median diastema.

With regard to the degree of distal occlusion, he was carrying out a survey of a rather more limited scope than Mr. Gardiner's, but he had so far been impressed by the relatively large number of cusp-to-cusp cases in Angle's Class II. In the figures which he had up to date they comprised about one-third of the cases which he would classify as Angle's Class II.

Dr. J. H. Scott asked whether Mr. Gardiner thought that 1000 was an adequate number. It seemed a large number, but when it was distributed from 6 to 15 years of age there was a very small number in each age group. That might explain the irregular results which Mr. Gardiner had obtained for some malocclusions. He thought it would be a great advantage if the number was increased to 5000.

He would like to know why Mr. Gardiner objected to the use of the term "edge-to-edge bite."

Had Mr. Gardiner come to any definite conclusion on the question whether there was any relation between the open-mouth habit and malocclusions?

It was possible that habits were less common in rural children than in urban children. It might be that the stress of modern living which was experienced especially in towns caused an increased tendency to habits of all kinds. He thought it would be worth while to carry out a parallel investigation on an equal number of children in a rural area.

He thought it was a pity that Mr. Gardiner had not carried out any investigations amongst the parents, brothers, and sisters of the children concerned. Even if he could get details only of the mothers it would be interesting.

Mr. J. C. Ritchie said he thought there would be a diastema between the central incisors if there was a powerful fibrous band passing between the two central teeth. He did not think that the removal of a triangular area of the frænum would do any good at all in the matter of reducing the diastema. He thought that the whole fibrous band had to be removed and dissected out right back to the incisive papilla. If that was done at the time of the eruption of the lateral teeth, the two central incisors would move together.

With regard to the hereditary factor, he had under his care at the moment four children who originally had a diastema. Their father had a very wide diastema. In three of the children a frænectomy had already been done and the diastema had closed by the age of nine years. It was now five years since the first one had been done and there was no sign of any recurrence.

At the moment he was carrying out a small investigation to discover why cross-bite occurred, and he thought that his conclusions would be reached fairly soon. He was certain that cross-bite had nothing at all to do with a sucking habit. He thought it was due to a lack of width in the upper temporary canine region at the time when these teeth were erupting. A small child was faced with an edge-to-edge bite, a two-point contact only, and for comfort and occlusion the child had to bring the mandible either forward or to one side or the other. He had under his care at the moment twenty children, between two and five years of age in whom cross-bite had been caused by an edge-to-edge bite.

Mr. H. E. Wilson, referring to the question of lost space following extractions, said it would be of some value if the loss of space was correlated with the time of the extractions and the age at which the investigation was carried out.

Mr. Gardiner mentioned nail-biting under habits, but it was more easily acquired and discontinued than other habits and was less harmful. When questioned, a child often admitted starting it because some school friend or near relation did it—a history more common with nail-biting than sucking habits.

Mr. A. F. D. Shapland, referring to the question of loss of space, said Mr. Gardiner had stated that 190 children were examined for loss of space and 80 per cent had shown some loss, and then he had said that 40 per cent showed no loss of space. Which was the correct figure?

Mr. G. C. Dickson asked whether Mr. Gardiner had taken any advice on the statistical significance of his figures. He thought it would be an advantage if they were subjected to statistical analysis.

Miss R. Caseley said she thought the diastema should be related to the stage of full eruption of the canines rather than to the age of the child, as the diastema often closed naturally at that stage.

The President asked whether Mr. Gardiner had taken extractions into account in his figures of median diastema.

Mr. J. H. Gardiner, in replying to the discussion, said he agreed with Miss Clinch that it was difficult to define "normal." He also agreed with her remarks about models. He thought that in future investigations models might well be taken, but in the investigation in question he had wanted to find a certain amount of information from observing a large number of ordinary children and he had not taken models. He agreed that they would have made the investigation much more valuable.

With regard to the question of when a frænum was persistent and when it was not, he had decided that purely by size. He had not included in the survey any frænum which was below one-quarter the distance from the highest point of reflection of the mucous fold down to the lowest point of the incisor papilla. The figures given were those of all fræna which were larger than that.

Miss Clinch's point about cross-bite and sucking habits was interesting, and he would look at his figures again from that point of view.

He had taken into consideration the question of cleanliness in assessing thumb-sucking. It had been more obvious in the boys than in the girls.

On the question of the tongue lying between the occlusal surfaces of the posterior teeth, he had taken the more extreme cases in which the tongue lay right over the occlusal surfaces and there were some markings on the lateral surfaces of the tongue.

He could not express any opinion yet on the question whether the tongue thrust or the open bite came first.

With regard to the assessment of open bite, he had sought to take it from some fixed point to include all those cases of deficient overlap of the incisors which otherwise could not be taken any account of at all.

In reply to Mr. Pedley, 6 per cent of the families were professional families (ministers, architects, school teachers, and so on), 9 per cent were the labouring class, and the rest were artisans, such as fitters, engineers, and so on. The majority lived in terrace houses.

With regard to Mr. Leighton's remarks, the missing teeth did not include third molars. It had not been possible to X ray all the children, so the figures were not as conclusive as the figures given by Dolder, who had employed a mass radiographic technique.

In connexion with tongue thrust the question of teeth-apart swallow had been investigated, and those with an open bite had been noted.

In reply to Mr. Hopkin, no parents had been investigated in the survey to see whether the median diastema was hereditary, but he had noticed, in the case of children attending hospital, that in some cases it was a condition inherited from one or both parents.

With regard to Angle's Class II cases, Angle had probably based all his figures on cases occurring in his own practice, so that they would all be fairly confirmed

cases of malocclusion, whereas the figures in the survey in question and in some of the other surveys were taken from ordinary children, whether they had malocclusion or not, so they would probably be very much lower. For instanee, he had found that there was a considerable discrepaney between his figures taken in the orthodontic survey and those from children who attended the clinie because they had malocelusion.

He agreed with Dr. Scott that 1000 children was not an adequate number in the case of some of the figures, and that applied especially to the older groups.

Units had been used in the assessing of Class II. He had used all units—canines, molars, and premolars.

The edge-to-edge bitc had been notcd, but he had not brought it into the results of the survey on the present occasion.

The point as to what malocclusions, if any, could be assoeiated with the open-mouth habit was an interesting one.

The question of the percentage of malocclusion in town ehildren as compared with country children would be well worth investigating.

He intended to investigate the correlation of loss of space with time of extraction and age at investigation.

It had been found that the information given by the children about the sucking habits of their class mates had to be checked with the schoolmistress.

He had not sought statistical advice yet, beeause hc had not reached the end of the survey. He realized that it would produce a number of changes.

Miss Caseley's point about relating the diastema to the eruption stage of the canines was another point which could be followed up.

With regard to the President's question about extractions, there had not been enough finance available to make it possible to investigate the dental history of all the children and obtain exact information on that point, but it was an important point in median diastcma eases. Obviously if a child had lost two upper first premolars one could expect more spacing of the anterior teeth.

On thc motion of the President, a vote of thanks was aceorded to Mr. Gardiner, and the meeting then terminated.

CLINICAL TYPES

By **E. GWYNNE-EVANS** and **W. J. TULLEY**
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Part I

(*E. Gwynne-Evans*)

I STAND here as an investigator of a problem that has almost overwhelmed me. Physicians and surgeons, when baffled, have the advantage of waiting for a post-mortem to learn the truth. A vast bulk of medical knowledge has been learnt by constant attendance in post-mortem rooms. Orthodontists are at a distinct disadvantage in this respect. The privilege of an autopsy rarely comes their way, and, if it did, very little help would be gained from an examination of the muscles, jaws, and teeth, in rigor mortis! Their studies are of life; the evolutionary history and embryology of structure and function; the maturation and fulfilment of Providence's design in every child they see.

The space of time allotted to an orthodontist for clinical examinations is limited to a few years—an infinitesimal period compared with the time-span of life. Yet, his task is to judge the interrelation of factors, inherited and environmental, that have contributed toward the form and behaviour of the facial structures at the stage of development when the child is first seen. Moreover, in order to plan his line of treatment, he is expected to predict the future, to assess the trends of growth, and, above all, to foretell the changes that will take place in facial appearances as maturation proceeds. As Tulley tells me, ". . . it is like a game of chess with the devil as your opponent. You come into it when the game has already begun; you are not sure of the moves that have been made or of the eventual outcome of any plan you may evolve to conclude the game!" However, the more experienced players are better able to visualize the moves ahead.

If we cannot gaze far into the future, we can at least look back, and through the medium of cine-films we can recapitulate the essential years of a child's development within the space of a few minutes. We propose to show such a film this evening with the hope of learning some of its lessons, although they may be in reverse. One will certainly be—that neither orthodontists nor parents, grandparents, or doting aunts and uncles can predict the future of a child's appearance even when the family traits are known.

We have been interested particularly in the life history of the orofacial muscles, within whose sphere of behaviour the dento-alveolar structures develop and function. For some years it has been known that muscle forces of the mouth can sometimes hinder the work of the orthodontist in re-alining the teeth, and moreover can be responsible for a relapse after treatment when, discontinuing the use of appliances, the teeth return to their original state of alinement for no other obvious reason.

It was thought by many workers, therefore, that if the science of orthodontics was to be further advanced, a reconsideration of the principles of neuromuscular activity was needed. I think it is greatly to the credit of orthodontists who have accepted this challenge that so much has already been accomplished.

We have learnt how, in segmental organisms like the earthworm, the reaction of each segment is automatic and invariable; how centralization of nervous tissue allows intersegmental reactions; and how special receptor organs are developed at the head end to allow the animal to react as a whole to external stimuli. How animals of a higher order have a supra-segmental system of controlling centres built up in the head to form a brain so that incoming and outgoing nerve impulses can be correlated and the reactions of lower centres can be modified to meet a specific situation. How in higher animals still, the controlling

Given at the meeting held on December 12, 1955.

centres shift forward in a process known as prosencephalization, and how the development of the cerebral cortex allows greater and greater elaboration of neuromuscular activity.

We are reminded how through aeons of time the central nervous system of man became organized; how the processes of evolution seem, in some ways, to be retraced and recapitulated in telescoped form during the period of uterine growth; and how when the infant is born the central nervous system and the sense organs are in an advanced state of development far beyond any effective use, but ready to respond to the outside world when the time comes.

Bartlett (1947) speaks of "behaviour" as when a good many different receptor and effector functions are interlinked, all joined in the pursuit and achievement of some task.

From the outset, the child is beset with tasks to perform. Groups of muscles react as a whole to accomplish a task whether in infancy it be suckling or in childhood it be chewing, crawling, or standing, etc. It is not necessary for a child to know how to accomplish these tasks. It is enough to know what to do; sensations and movements grow out of the setting of the task and even errors in coordination are corrected automatically. Success leads to further tasks, and so the processes of maturation proceed.

When the time comes to use the special senses and the highest levels of cortical control, mass movements are inhibited to allow the outgrowth of individual movements, and so, out of the enormous substratum of basic behaviour, a capacity for learning proper commences side by side with the processes of maturation. Contacts with the physical and social world play an important part in modifying behaviour.

A child would never talk if his auditory impressions were not linked with the movements of the tongue, soft palate, and lips originally concerned only in feeding and in expressing his feelings. But no child could ever be taught to differentiate one movement from another in the formation of sounds that have meaning unless he already possessed by inheritance the necessary machinery of the central nervous system.

The orofacial muscles come more and more under conscious control. Side by side with the stereotyped inborn reactions common to all, come the formation of habitual movements that are specialized, as in speech, and differ from race to race. Gradually, highly skilled movements that depend on the absence of habit formation and stereotyping for their effectiveness add to the extreme versatility of orofacial behaviour. The soft tissues, and their behaviour, continue to be modified throughout life, and it is extremely difficult to say how far the facial characteristics of any individual are a credit to nature or to environment.

It may be wondered how all, or any, of this knowledge can possibly be applied to the practice of orthodontics. Yet, principles of neuromuscular activity have already been borne in mind, particularly when using that ubiquitous and fascinating appliance of Andresen, the "monobloc".

Some years ago, Rix (1946) described an atypical pattern of orofacial behaviour in swallowing where, in the predeglutitionary phase, the teeth do not occlude and the tongue is spread or thrust forwards between the teeth against contracting lips. Ballard, Tulley, Whillis, and myself expressed hopes that the monobloc might be used to supply the mouth with a new pattern of sensations on swallowing which would correct this atypical behaviour. With the appliance loose in the mouth, subconscious acts of swallowing are initiated to empty the mouth of excess saliva. It was hoped that the muscles would thus be set a frequently recurring task in which the teeth are integrated automatically with the outer circumference of the appliance, so that the movements of the tongue would be strictly confined within the boundaries of a closed oral cavity, and the lips would be relieved from contracting to restrain the tongue. It was thought that these new sensations and movements would bring about a change in the swallowing behaviour of the orofacial muscles so that in time the child would swallow normally, i.e., with the teeth integrated together, the tongue spread against the dental

arches, and the lips closed with little or no contraction.

The film will show how little our hopes of success were justified. Seeking for an explanation of our failure, I turned to study the anthropological history of the orofacial muscles. As I indicated in my paper to the European Orthodontic Congress last year (1954), it was then that I began to realize how much of the orofacial musculature derived its origin and innervation from visceral elements. I still believe that the swallowing behaviour of the orofacial muscles reflects their visceral origin in some children more than in others, and that this may be the probable explanation of many atypical patterns of behaviour. I know some workers may not agree with me, but I am struck by the similarity of atypical swallowing patterns when individual variations are discounted, such as a passive upper lip or a contraction of the lower lip with no forward thrust of the tongue. Some conform exactly to a set pattern of behaviour, and in my view there must be a reason, with a common denominator found for many of them. These observations are clearly demonstrated in the film.

There is no doubt that lower or more automatic processes are inherited more directly than higher processes. It is quite likely that individual characteristics of the atypical swallowing behaviour are inherited. Thus, it is not surprising to find it is difficult to modify patterns of behaviour as are produced in swallowing.

I cannot help feeling that as the child grows up, some atypical elements become less noticeable. Such impressions illustrate the importance of carrying out a serial study as portrayed in our film, and I hope, in twenty years from now, I shall again see this film to which others have added pictures of the same children in adult life. By then perhaps we might have learnt something from this method of approach.

Many and varied are our investigations. In fact, so much has been written in recent years that it would be impossible to read all the literature, and I may be in ignorance of all the ground previous workers have covered. I hope I shall be forgiven, therefore, if I mention only two names—Ballard and Tulley. Both these workers have made, and are still making, important contributions to our studies. Ballard (1953, 1955) has reviewed the literature concerned with the evolutionary background of function and he has made special studies of the biology of soft-tissue behaviour. Tulley (1953) has taken many recordings of action potentials among the orofacial muscles in the act of swallowing by means of the electromyograph.

These and other studies are essential to increase our knowledge. But what of their practical application? In practice we are dealing with muscular movements—not with the origin of them. We want to track down forces arising from them that impede our plan of treatment. One might say that if we want to track down a lion we send for a hunter and not for a zoologist! This may be true, but those who are working quietly and laboriously at what seems to be obscure are bound, in time, to make advances in diagnosis; for after all, treatment depends very much on whether we know what can or should be treated.

It was Moxon (1868) who said: "You must know diseases not as the zoologist knows his species—but as the hunter knows his lions and tigers." But, as Hughlings Jackson (1932) remarked later, "I thoroughly agree with this in so far that we should try to know diseases as the hunter knows his lions and tigers, but I think we should endeavour to know them also as the zoologist knows his species". Although we are not dealing with diseases, but with disturbances of growth and function, the lessons to be learnt from these statements are just as applicable.

When we take clinical notes we make an empirical arrangement of facts as a gardener would arrange his flowers to suit his purpose. Empirical studies come first because they are forced upon us. Scientific studies come later to sort out and re-arrange facts in their right order and relationship as a botanist would arrange his garden.

Thus, through increasing knowledge, an empirical arrangement of individual facts may be converted into a classification of interrelated facts. The danger lies in building up

a system of classification on errors in correlation. Some investigators in the past have made wrong correlations that have been popularized and propagated from one textbook to another. An outstanding example is the type of face that has been correlated with overgrowth of adenoid tissue and chronic nasal obstruction which has been classified as the "adenoid facies".

We have correlated various dento-alveolar deformities with particular patterns of tongue and lip behaviour. A natural sequence to this correlation is the hypothesis that the teeth are alined within a state of balance between the muscle forces surrounding them (Ballard). Some may ask—where is the proof? There is no proof. A hypothesis is not a conclusion; it is a starting point for observations and it should not be repudiated for want of scientific proof (Hughlings Jackson).

We are dealing with compound questions; it is the interrelation of structure and function that matters, and a defect of one part should be considered as a flaw in the whole. With these ideas in our minds Tulley and I began to arrange and classify our clinical material and to make generalizations by evolving clinical types. Some seemed to be true to form, some were intermediate: others were mixed.

Study by typing is a scientific method of approach; but great clinical experience is needed. There are always exceptions to the rule and individual peculiarities; these might be so complicated that even the types we evolve may cease to be typical.

Nevertheless, I believe the most practical way of specifying interrelated forms of structure and function is to classify them in terms of clinical types in which the facial skeleton, the jaws, the teeth, and the orofacial muscles are considered, not separately in isolation from each other, but together as a conjoint whole.

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PART II
(*W. J. Tulley*)

Following Gwynne-Evans's survey of some of the problems facing the research worker I want to make some down-to-earth comments on the applications of this research. We must be careful not to evolve too specialized a terminology so that our jargon is not understood by other members of the dental profession. It has already been indicated, and I would stress it again, that orthodontics is essentially an art and there is a danger in attempting to make it an exact science. Man's face has many variations and cannot be reduced to a geometric problem.

Research workers are studying the growth trends of the facial skeleton by cephalometric X rays; the electromyograph is being used to study the behaviour of the muscles; serial models are being used to study changes in the occlusion; and Gwynne-Evans and I are studying the changing facies of children by serial cine-film. Where is all this leading? I suggest that it is making for better diagnosis and prognosis. We are more conscious of the limitations of orthodontics, but I do not think it has changed our methods of treatment very much.

I would be the last to decry progressive research, which must continue, but the time has come for us to take stock and apply what we have learned over the last few years to our appraisal of each patient. We dissect our patient's faces into a skeletal pattern, a pattern of soft-tissue morphology, a dento-alveolar pattern, a posture and behaviour pattern of the lips, cheeks, and tongue, for purposes of diagnosis. However, we must recognize that

each of our patients has these factors integrated to form a clinical entity which the experienced orthodontist comes to recognize. He gets the feeling that a patient presents a similar problem to little John Willie or little Mary Ann.

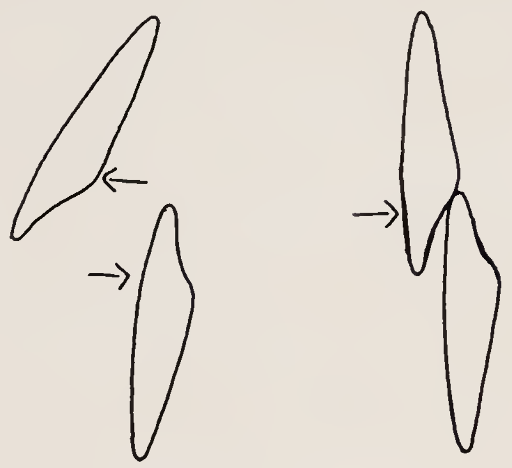


Fig. 1.—Varying incisor inclinations associated with abnormal soft tissue forces. A, Dispersal of incisor relations; B, Close adaptation of incisors with tendency to retroclination.

He develops a clinical sense and an ability to recognize the adverse forces likely to oppose the treatment and jeopardize stability.

Earlier this year, our President showed "Long Term Results of Orthodontic Treatment" (Pringle, 1955). In some of these cases there had been a relapse associated with adverse muscle forces; others had remained stable. Even now we are unable to forecast when modifications of soft-tissue behaviour will occur (Tulley, 1953). Ballard (1955) is convinced that these abnormal muscle forces are products of an endogenous behaviour which cannot be fundamentally changed. The superimposition of acquired habit movements may be the reason why changes in behaviour have been reported. While appreciating Ballard's views, I believe that subtle changes in oromuscular behaviour may occur with time and during treatment.

In the discussion following Pringle's paper, Hovell made this statement, with which I am in agreement: He thought "the chief lesson to be learned from the President's address was that the most important thing in orthodontic treatment was the need for ultimate stability of the upper and lower incisor teeth within muscle balance. In the old days, when orthodontists knew nothing about skeletal patterns they had put the teeth into correct relationship with the lips and had obtained good results, which did not relapse very much. He thought that they should return to observing the soft-tissue behaviour and should avoid the mechanistic approach to orthodontics which was likely to arise from too great a consideration of skeletal patterning factors with attempts to produce ideal relationships often unattainable or unstable".

Fig. 2.—Normal balance of lingual and labial forces in teeth together swallow. Normal incisor relationship.

Ballard, in the same discussion, said: "If a study of soft-tissue behaviour indicated what was going to be the stable end-result, orthodontists should not regard a case as a failure if, in the end-result, the incisors were not in the position which the text-books stated to be the ideal occlusion."

These two statements set the stage for a swing of the pendulum away from a too rigid scientific approach to the subject. Gwynne-Evans, at the meeting of the European Orthodontic Society at Eastbourne, and again in this paper, has emphasized the importance of looking at each child as a clinical entity, and through the medium of the cine-film we are going to show a few of the various types of facial form and function which we meet in orthodontic practice and indicate where there is a possibility of making a compromise with nature and where that possibility is very remote.

Among the many variations of the atypical (teeth apart) swallow described by Rix (1953) in his paper "Some Observations on the

Environment of the Incisors", two sharply contrasting types are recognizable:—

1. Where the actions of tongue and lips are associated with a dispersal of upper and lower incisor relations (*Fig.* 1 A).

2. Where the tongue does not thrust forward to exert any force on the lingual surface of upper and lower incisors. The lips may or may not contract excessively and the closely applied upper and lower incisors are upright or retroclined.

Figs. 1 B, 2 show the normal balance of lingual and labial forces.

I shall be accused of oversimplifying the subtle differences, but I think this can be justified in order to make the subject clear. The film is designed to illustrate some of these variations and the relationship of the basic jaw elements will be described using Ballard's classification of apical base relationship: e.g., Skeletal 1 where there is a normal antero-posterior relationship between the jaws; Skeletal 2 where there is a mandibular retrusion or maxillary protrusion; and Skeletal 3 for the reverse relationship (Ballard, 1948).

Angle's Class I.—In patients presenting with Angle's Class I malocclusions the teeth are often based on jaws which are inadequate to accommodate them all in good alinement. Even if the apical base is adequate the soft tissues of cheeks and lips at rest and in function restrict full centrifugal development of the dental arches on their bony bases. Both these adverse factors may coexist, and, although it has been said many times, I stress it again, if the end-result is to remain stable extractions are inevitable. This is true for the majority of Class I cases.

The first and other special type of Class I malocclusion shown in the film (*Fig.* 3) is where

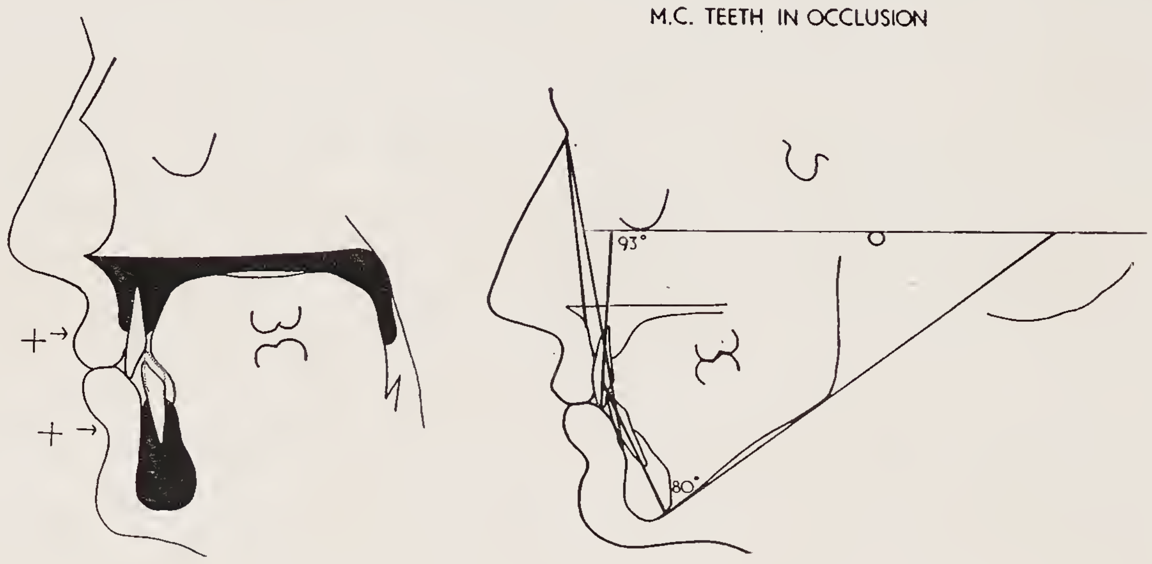


Fig. 3.—A, Diagram of muscle forces in swallowing. Class I case. Note teeth apart, excess lip activity. No forward spread of tongue. Retroclination of incisors with deep overbite; B, Tracing of lateral skull radiograph showing retroclined incisors. Not possible to move them labially because of soft tissue behaviour and morphology.

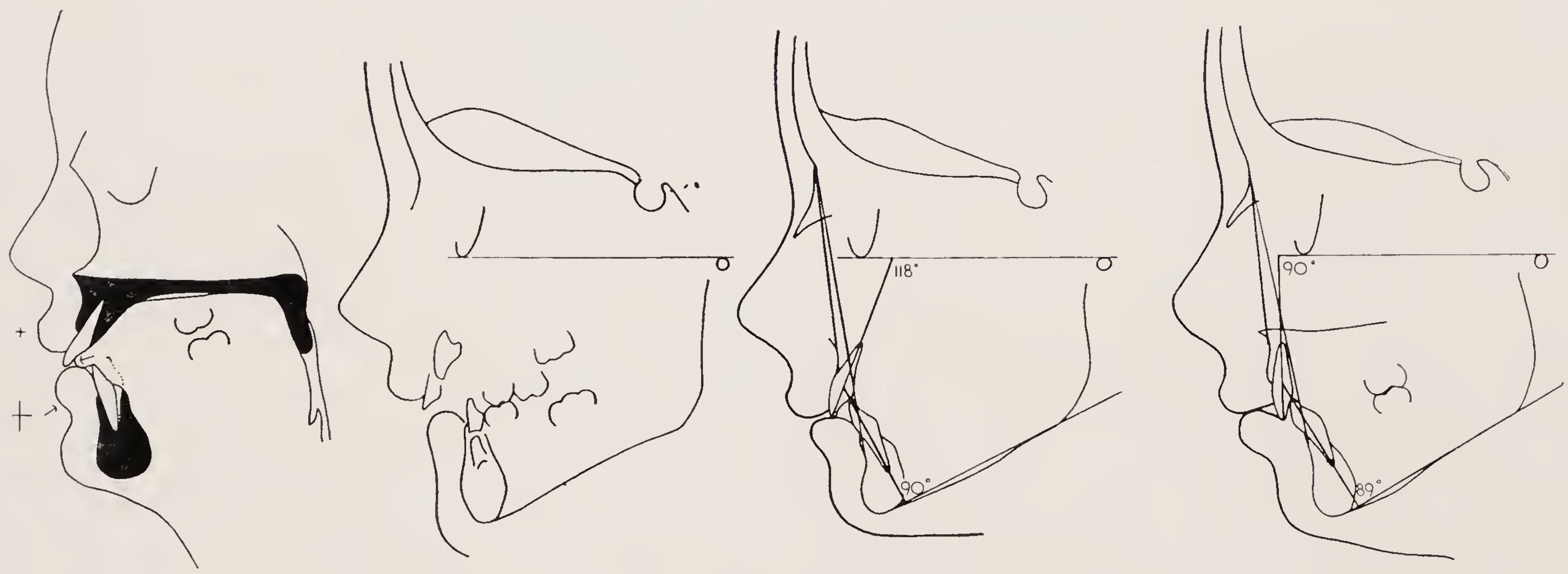
the apical base relationship is normal antero-posteriorly but both upper and lower incisor segments are retroclined and somewhat crowded, and a deep overbite is present. In swallowing there is excessive lip activity; the cheek teeth are widely separated but the tongue does not come forward to contact the lingual surfaces of upper and lower incisors. Rix refers to this as the "blunt tongue swallow". Treatment in these cases is difficult, as it is often impossible to move upper and lower incisors forward in the face of lip pressures. If the crowding is slight it is better left alone. Extractions in the upper arch may allow some improvement in upper incisor alinement, but reduction in the lower arch will only induce further collapse. The dental condition is not necessarily secondary to the muscle forces, but from the practical view both are part and parcel of the whole clinical entity. The second type of Class I case presented (*Fig.* 4) is one where there is crowding in both arches, with a slight overjet. There is a generalized constricting effect of both lip and cheek muscles during swallowing. The teeth are apart and the tongue spreads forward between

the incisors. In these cases a cross-bite may be present which is not usually seen in the previous type with the "blunt tongue swallow". In the case illustrated there is no cross-bite in the molar region; all round extractions were is made. Despite this the lips are not sealed at rest.

Angle's Class II, Division 1.—Four of the many variations of this type of malocclusion are presented. The first (*Fig.* 5) is where a

A B

Fig. 4.—A, Diagram of muscle forces in swallowing. Class I case. Note teeth apart, excess contraction of lips in swallowing. Forward spread of tongue, open bite, and overjet; B, Tracing of lateral skull radiograph.



A B

Fig. 5.—Diagram of muscle forces in swallowing. Class II, Div. 1 type. Class I skeletal relationship. Note teeth apart, marked contraction of lower lip under upper incisors. Forward spread of tongue; B, Lateral skull tracing showing treatment by monobloc. Not stable until upper incisor behind lower lip.

necessary to complete incisor alinement. A slight overjet remains owing to the persistent forward spreading of the tongue. A similar case shown in the film illustrates that the morphology of the soft tissues, as well as their abnormal function, plays a constricting role and resists expansion of the arches. The oral fissure is small and the cheeks tensed when a digital examination of the mouth Class II, Division 1 malocclusion is found on a Class I skeletal base. The action of lips and tongue during swallowing is associated with a dispersal of incisor relations. The tongue spreads forward against the upper incisors and the lower lip contracts strongly under them. Treatment in such cases depends on the strength of these adverse forces. If by one means or another the upper incisors can be

retracted behind the sphere of influence of the lower lip so that it can act on their labial surfaces, stability is more likely. In some cases there appears to be a modification of behaviour, particularly of the tongue.

The second type (*Fig.* 6) is where a Class II, Division 1 malocclusion exists on a skeletal II base. In swallowing, adverse effects of tongue thrust and lower lip contraction may be accentuated, the lower lip having

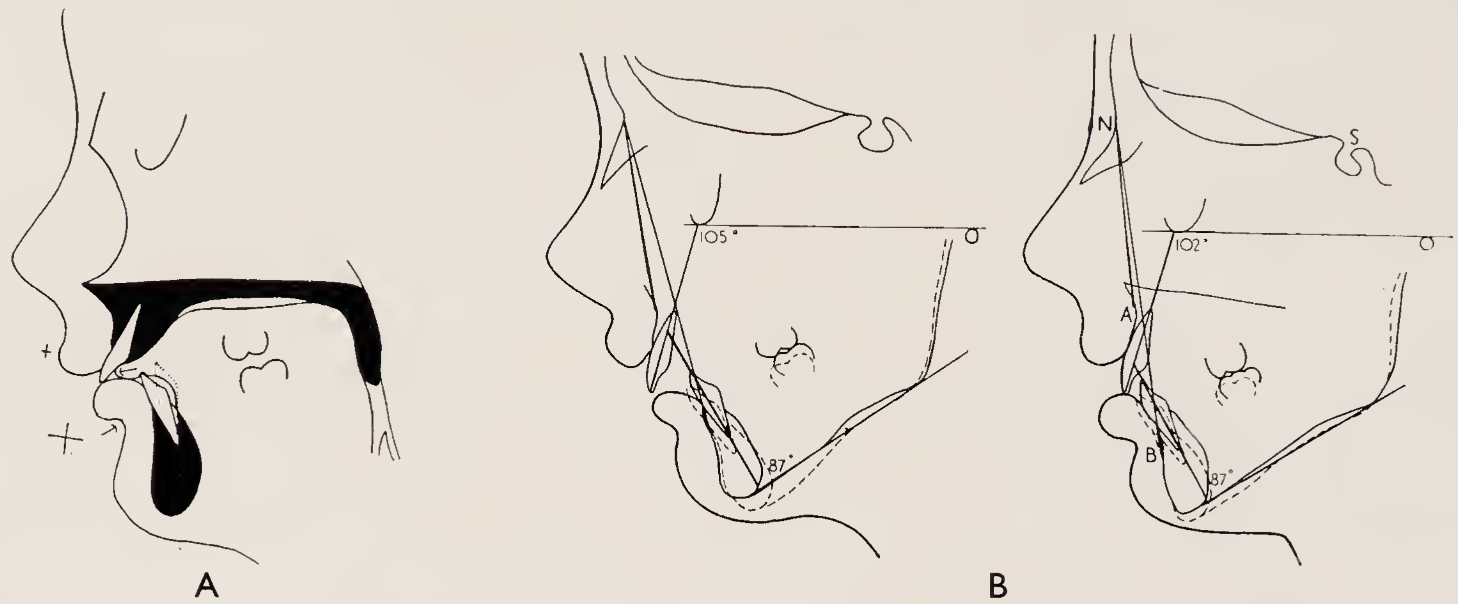


Fig. 6.—A, Diagram of muscle forces in swallowing. Class II, Div. 1 type. Class II skeletal base. Note teeth apart, strong contraction of lower lip. Forward spread of tongue. Dotted line indicates what tends to occur if teeth lost in lower arch. B, Tracing before and one year after treatment. Lower lip now brought up high on labial surface of upper incisors in swallowing. Dots indicate rest position.

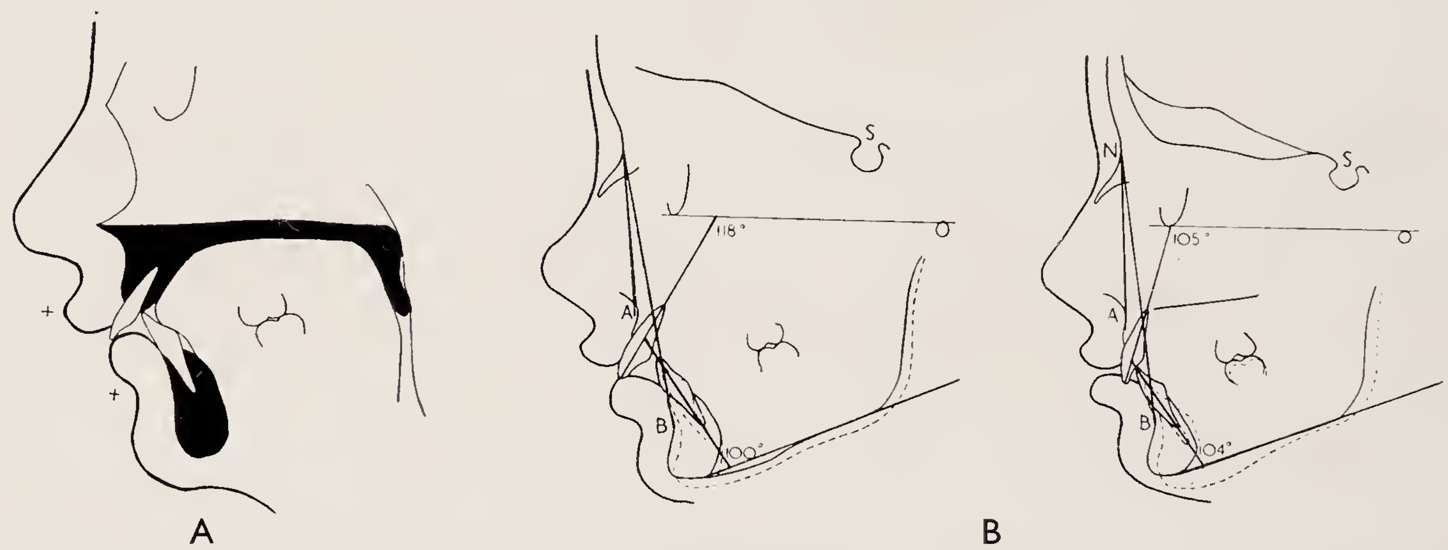


Fig. 7.—A, Diagram of favourable muscle forces in swallowing. Class II, Div. 1 type. Class II skeletal relationship. Teeth together swallow. Lower lips not active. B, Lateral skull tracing before and after treatment.

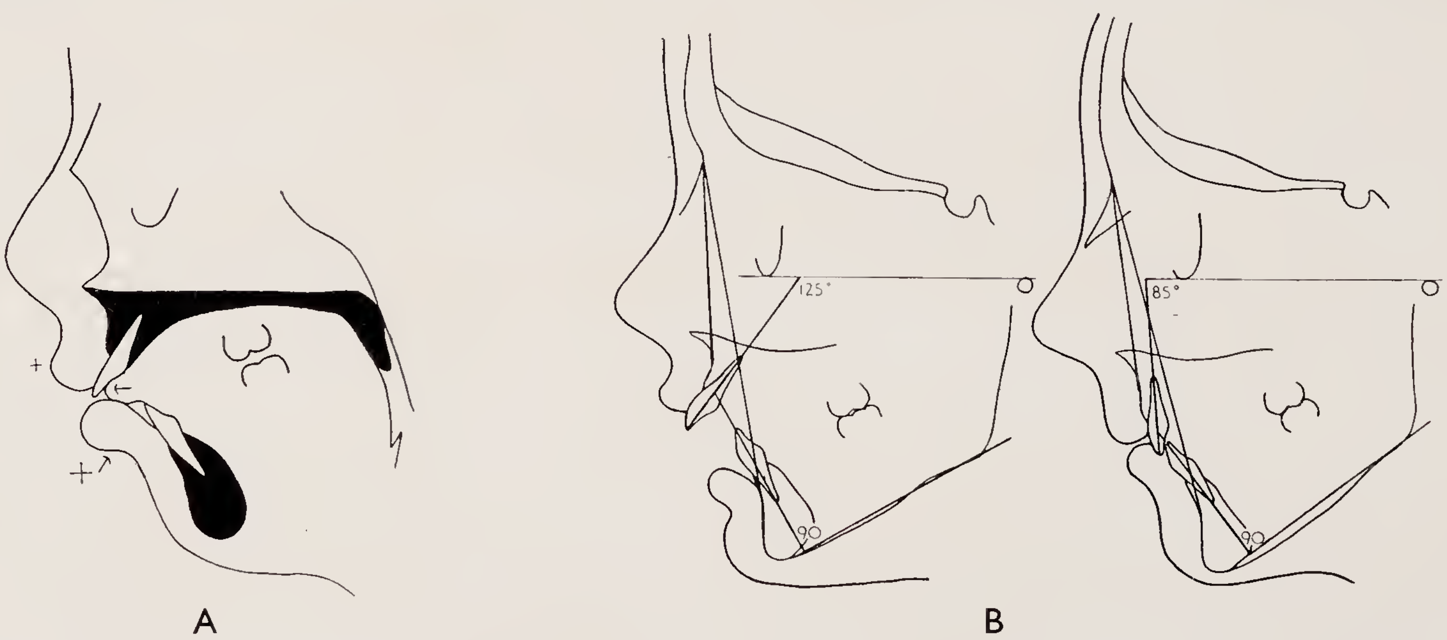


Fig. 8.—Diagram of muscle forces in swallowing. Class II, Div. 1 type with open bite. Forward spread of tongue a constant feature. Teeth apart, lisping speech, tongue/lip resting contact; B, A treated case not stable because of soft tissue behaviour.

a greater mechanical advantage. Here again treatment must be designed to retract the upper incisors behind the activity of the lower lip by one means or another, but because of the skeletal abnormality and the degree of adverse force it may be difficult and nearly always requires a reduction in the upper arch. It is worth attempting treatment provided the skeletal relationship is not too severe. A modification of lip behaviour may be achieved partly by habitual control, even if there is some relapse.

The third type (*Fig.* 7) is with a Class II, Division 1 malocclusion on a skeletal II base. The underlying behaviour is not atypical insofar as the teeth are occluded in swallowing and the tongue is acting in a rigid walled cavity (Rix, 1953). The lower lip is trapped under the upper incisor teeth purely because of the malrelationship of the jaws. It plays a passive role and is a secondary factor. Where the skeletal malrelationship is not too severe and upper incisors can be retracted there is no tongue thrust or lip contraction to cause relapse. This case is contrasted with her sister (*Fig.* 8) who also had a Class II, Division 1 malocclusion on a mild skeletal II base with an anterior open bite. Here the behaviour of the soft tissues is not favourable. There is a constant forward spread of the tongue between the teeth and a marked contraction of the lower lip. The difference here is the tongue-lower lip contact which persists not only during swallowing but at rest, and is often associated with an interdental lisp (Ballard, 1951a, b). This type of activity can occur in a Class I, II, or III case and is most persistent. *Fig* 9 shows father and daughter

A B

Fig. 9.—Class III with open bite. Tongue rests between incisors and both have lisp and persistent spread of tongue. A, Father, showing rest position of tongue; B, Daughter, showing rest position of tongue.

with Class III malocclusions, open bite, and lisping speech.

Angle's Class II, Division 2.—The classical type of Angle's Class II, Division 2 malocclusion often occurs on a mild skeletal II base (*Fig.* 10). It is a clinical entity about which surprisingly little is known. The oromuscular behaviour is similar to that described in Angle's Class I cases with retroclination of upper and lower labial segments. The tongue does not come forward between the incisors or thrust against their lingual surfaces, but there may not be any excessive contraction of the lips. The morphology of the lips in relation to the alveolar process and teeth is all part of the clinical picture, which to my mind cannot be explained simply in terms of muscle forces. Forward movement of the upper incisors is discouraged, and even when teeth are removed from the buccal segments the lateral incisors may tend to return to their original positions. *Fig.* 10 primary aetiological factor, will dictate the degree to which lower incisors can be collapsed lingually during orthodontic treatment (McCallin, 1956).

In postural Class III cases Rix (1953) describes the separation of the cheek teeth

Fig. 10.—Diagram of muscle forces in swallowing and soft tissue morphology. Class II, Div. 2 type. No forward spread of tongue. Teeth apart swallow. Lower lip may not contract excessively but acts high on labial surface of upper incisors.

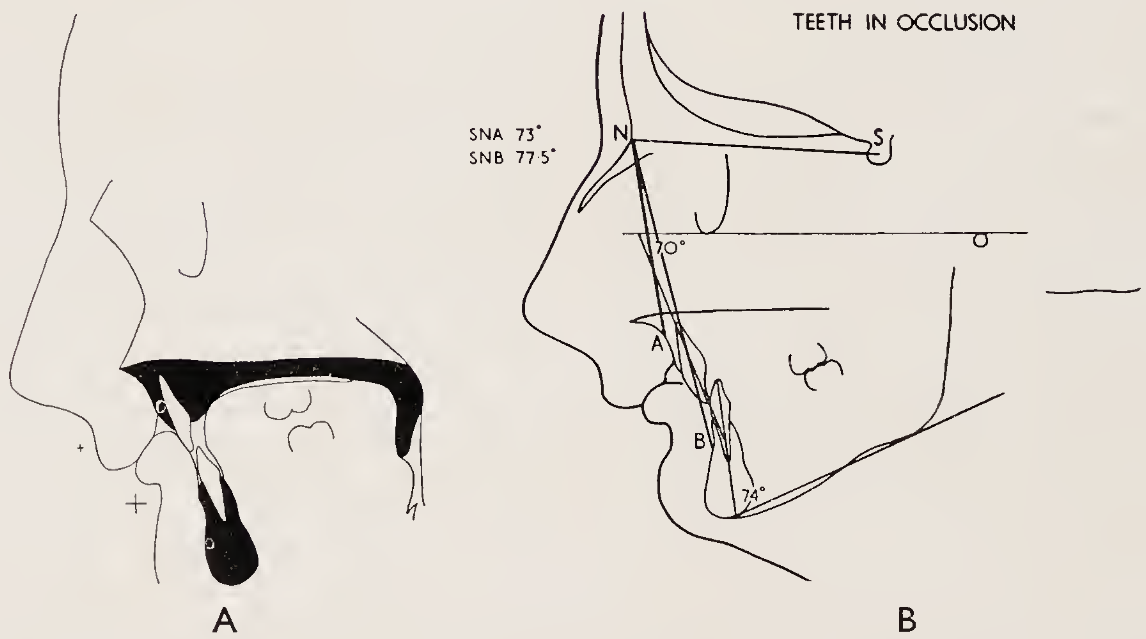


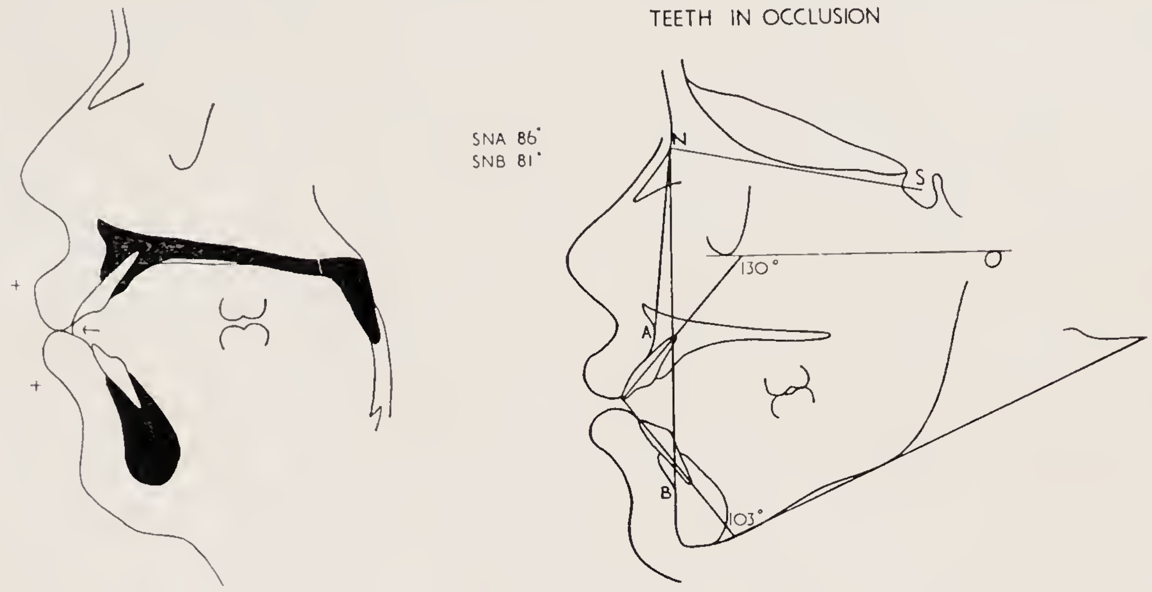
Fig. 11.—A, Diagram of muscle forces in swallowing. Exaggerated case Class II, Div. 2 type. Teeth apart, excessive lower lip activity. No forward spread of tongue, incisors retroclined; B, Tracing of lateral skull radiograph showing soft tissue morphology and incisor inclinations.

illustrates a fairly typical sort of picture and *Fig.* 11 shows a very extreme case for which no treatment was desirable or possible.

Angle's Class III.—In cases of Angle's Class III malocclusions where the apical base relationship is Class III the skeletal pattern dominates the clinical picture. The teeth are apart in swallowing and Rix describes the tongue as being cushioned between all of the teeth at the mylohyoid phase. The morphology and function of the tongue, although not a during swallowing as sufficient to cancel out the reverse overbite. The tongue tends to sit between the cheek teeth and the incisors are placed in light edge-to-edge contact.

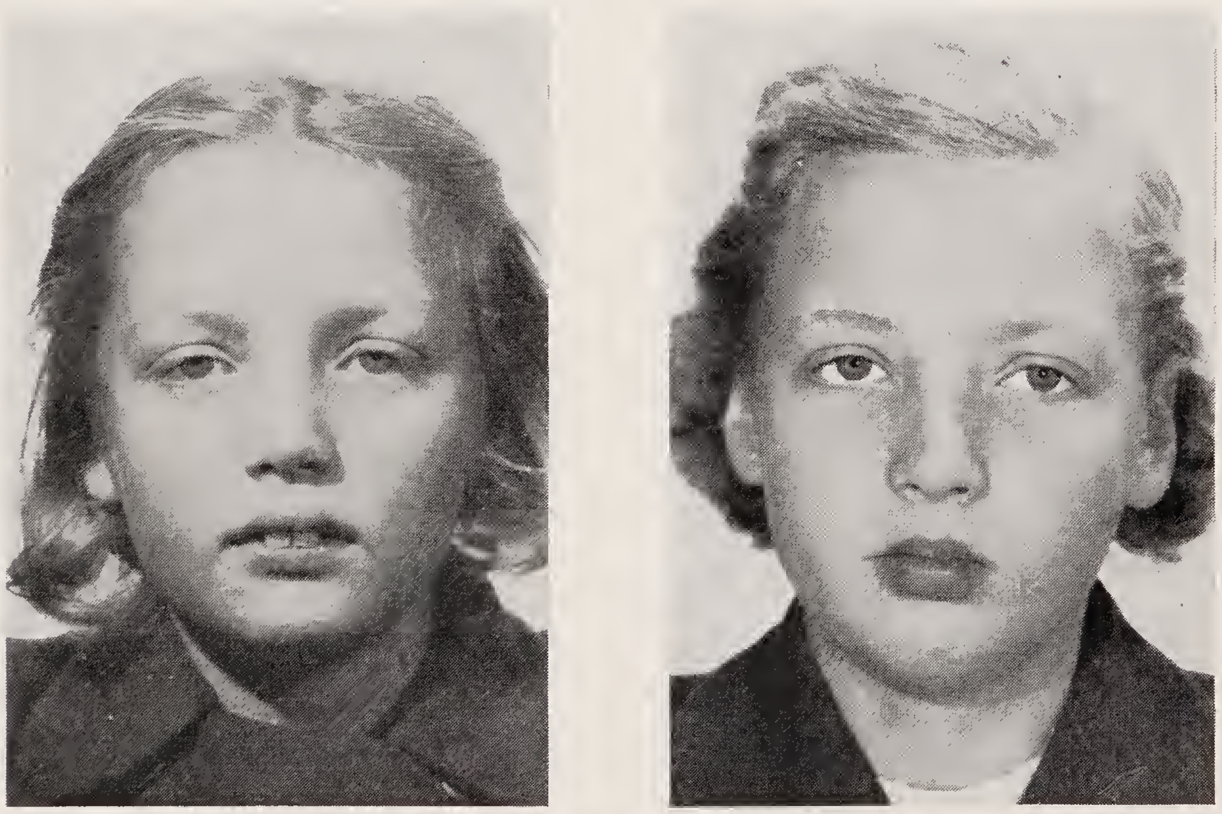
Bi-maxillary Protrusion.—The term "bi-maxillary protrusion" is one that refers to excessive prognathism of the jaws or to excessive proclinations of upper and lower labial segments on normal jaws. Where there is a true bi-maxillary prognathism the skeletal pattern dominates the clinical picture.

A case of this type is illustrated in *Fig.* 12. There is very adequate development of the dental arches, the tongue is large and spreads forward, the teeth are not placed together when swallowing, and the lips are rather flaccid and thick. Orthodontic treatment is doomed to failure because of the basic skeletal form and size and behaviour of the tongue. The case illustrated is the diametric opposite clinical type to the extreme Class II, Division 2 shown previously (*compare Figs.* 11, 12).



A B

Fig. 12.—A, Diagram of muscle forces in swallowing. Bi-maxillary protrusion. Note teeth apart, lips large and flaccid. Forward spread of tongue; B, Tracing of lateral skull radiograph showing soft tissue morphology and incisor inclinations.



A B

Fig. 13.—A case from the film series. Treated by extraction of $\underline{4|4}$, retraction of $\underline{3|3}$, followed by $\underline{21|12}$. A, At 10 years of age; B, Same case at 12 years of age. Note change in general features. Combination of growth, orthodontic treatment, maturation, and acquired habit. Lip seal achieved by conscious effort.

To summarize, this paper has attempted to collect together the original work of many people and put it into a condensed form for the orthodontic practitioner. A full bibliography is appended to clarify individual contributions to the study of soft-tissue morphology and behaviour.

A few of the many types of facial form and function have been shown. To replace the film, in the paper as here set out, line diagrams have been used to emphasize adverse facial morphology and muscle forces that must be recognized in making an orthodontic diagnosis. The ultimate position of the teeth following treatment must be in a position of balance

between the labial and lingual forces if they are to remain stable.

Studies by serial cine-film have shown how the face matures and develops during treatment (*Fig.* 13). This in the great majority of cases favours the orthodontist considerably. Such a film study shows a new approach to orthodontic follow-up, but is complementary to serial studies of occlusion with models and skeletal growth with lateral skull X-rays.

The paper was illustrated by a cine-film.

Acknowledgements.—Thanks are due to Mr. R. E. Rix and Mr. K. E. Pringle for their help and permission to show cases under their care at the Dental Department for Children, Guy's Hospital: to Miss Treadgold, Mrs. Rawlins, and Miss Howard for the preparation of drawings; to Miss Whiteley, of the Dental Photographic Department, for the preparation of slides; and to Mr. Colwell for the preparation of acrylic models shown in the film.

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DISCUSSION

Mr. R. E. Rix, in opening the discussion, said he thought that the film which the authors had shown would make an excellent teaching film, for it brought together a wide range of behaviour and malocclusion and in faet covered most of the conditions with which orthodontists had to deal. In some of the children shown in the film the adverse behaviour seemed to become a trifle less intense as the years passed, but in none of them had it shown a radical change. He hoped that the children would still be followed up.

He had been interested in the axial inclination of the lower incisors in the cases shown. He had noticed that where the behaviour was approaching normal or where a good result or an improvement had been obtained the inclination was in many cases well over 90° to the mandibular plane, and that in the cases where the behaviour was adverse the axial inclination was not very much under 90°. That made him wonder whether 90° should be accepted as the usual angle for a British child of 7 or 8 years. In a paper in 1952 he had shown a child of 9 years, with normal behaviour and normal occlusion, whose lower incisor inclination was well over 90°.

In planning their papers and film the authors had wanted "to track down forces in the orofacial muscular behaviour which would impede treatment". They did not dismiss the hypothesis that "the teeth are alined within a state of balance between muscle forces surrounding them", but they said that they could not prove it. He thought that they virtually implied proof when they pointed out the difficulty of treating cases with orthodontic forces which ran counter to muscular forces.

The authors had shown a series of clinical types, and their selection appeared to have been primarily morphological and, if they were still undecided about whether the egg or the hen came first, a morphological selection seemed as feasible as any other; but if one was trying to discover which came first he thought that the authors' typing had its weaknesses, for it was possible to misinterpret associated muscle behaviour. If a person's upper incisors were proclined and he did not put his teeth together when he swallowed, he could not do otherwise than either thrust forward his tongue to fill the space and tighten his lower lip at the same time, or just bite down on his lower lip. The former behaviour was by far the more common. The time when behaviour was likely to be particularly critical for determining incisor relationship was just prior to and during the eruption of the incisors. If the behaviour was "infantile" the lower incisors tended to be held back and the upper incisors tended to be encouraged forward. After the teeth had fully erupted and their malrelationship had been established, the diagnostic value of the forward tongue had lost most of its real significance. Its true dispersing behaviour, such as it might have had in conjunction with the tight lower lip, was now clouded over with secondary and inevitable behaviour.

It seemed to him that a knife edge could separate the false from the true as far as dispersing behaviour was concerned. A beautiful example of this had been shown in a paper and film produced by Mr. Leech a few months ago. He showed identieal twins, one of whom had an Angle Class II, Division 1 malocclusion and the other an Angle Class II, Division 2 malocclusion. The intensity of

the particular behaviour was only slight and seemed clinically about the same in the two cases, but at the time when the film was produced the incisors had fully erupted. There was the inevitable tongue thrust in the child with the Angle Class II, Division 1 incisor relationship, but not in the child with the Angle Class II, Division 2 malocclusion. It became all too easy to talk of two fundamentally different types of behaviour (and, if they had been included in the present film, to talk about two fundamentally different clinical types of child), but he thought it was likely that one of the children in Mr. Leech's paper was producing during the critical time only the merest suspicion of basically different behaviour. A hair's breadth at one time separated the significant from the indeterminate as far as dispersing behaviour was concerned.

Very many children could be included in this category. The sight of the tongue coming forward beneath proclined incisors often produced an ominous shake of the head and out came the phrase "obvious tongue thrust", but the prognosis for closely related incisors after treatment in this group was very good. It was easy to move the dispersed upper incisors back until they came, now that they were fully erupted, within the sphere of the slightly tight lower lip during swallowing. It did not even require a modification in the real basic behaviour, although it did require a marked change in that added portion of behaviour which automatically arose when the incisors were fully erupted and dispersed. He made this point because to group children into clinical types according to their established malocclusion could lead investigators away from a true appraisal of muscular behaviour.

In the group of children under the general heading of Class III shown in the film, there was a child with the postural Class III who separated the jaws until the incisor overlap was reduced almost to nil during swallowing. He would like to ask the authors whether they believed that this type of behaviour fell into line with their general hypothesis. A postural Class III could arise by accident, through the gross loss of deciduous molars before the upper and lower permanent incisors had erupted sufficiently to form a normal overlap. Did the authors suspect that the behaviour might be secondary to the malocclusion?

There were, of course, other cases in which the morphology of the dentition could lead to error in assessing the significance of behaviour. There was the anterior open bite that produced the lower lip in contact with the tongue. The lower lip was in contact with the tongue during swallowing just because of the anterior open bite. There was another variety of anterior open bite which arose just because the lower lip was in contact with the tongue. Those were two totally different conditions with different prognoses.

He wished to point out that if one typed according to significant muscular behaviour progress must be very slow to avoid the acceptance of wrong conclusions, but it would be the most profitable in the end.

Mr. J. H. Hovell said he was in agreement with 99 per cent of what the authors had said in their papers, and he thought they had made a very valuable contribution to orthodontics.

He thought that the authors in their clinical types had not differentiated sufficiently between morphology and action relative to both skeletal morphology and soft-tissue morphology. He would like to draw attention to their case of bimaxillary prognathism which Mr. Tulley had described as a typical bi-maxillary prognathism in which skeletal pattern dominated the picture. It was a skeletal Class III case. It also had tongue thrust, which dominated the picture considerably, and he thought there was a soft-tissue morphology which dominated the picture in the production of the bi-maxillary prognathism. He thought that "bi-maxillary proclination" would be a better term for it. In Angle Class II, Division 2 the same sort of thing occurred. One could get a soft-tissue morphology producing a bi-maxillary retroclination quite as severe as the one which Mr. Tulley had shown, with a teeth-apart swallowing action. He thought that the bi-maxillary retroclination of the incisors was due to soft-tissue morphology acting upon the alinement of the teeth and also on the position of the dental base relative to the skeletal base.

He did not like Mr. Tulley's term "clinical types", as he thought it was misleading. It was necessary to consider a combination of soft-tissue action and soft-tissue morphology relative to skeletal pattern. He did not think the cases could be typed at all.

With regard to Mr. Gwynne-Evans's remarks on the genesis of abnormal behaviour, surely if it were of visceral origin it would be more prevalent in the lower animals than it was in human beings, but it seemed to be much more prevalent in human beings. The explanation might be that the increasing specialization of the orofacial musculature had led to an increased tendency to various types of disharmony and dysfunction.

Mr. C. F. Ballard said he thought that Mr. Tulley disliked the phrase "incompetent lip posture" and did not use it. He thought that the incompetent lip posture was of as great importance as the tongue thrust behaviour, and, although he himself did not like the expression, he regarded it as as a simple way of explaining the lips apart posture. It meant that the lips were incompetent to produce an anterior oral seal when the mandible was in the "rest position" and when the muscles of facial expression were in their resting position. He would like to know whether Mr. Tulley had a better expression than "incompetent lip posture", because, if so, he would like to use it in future.

He believed that a Class II, Division 1 labial segment relationship could be produced from the incompetent lip posture, without any tongue thrust behaviour; in other words, the necessary effort to produce an anterior oral seal when swallowing and during speech came mainly from the mentalis muscle, which held back the lower labial segment. The relatively inactive upper lip plus a degree of anterior-posterior crowding would produce a proclined upper labial segment. He thought that when once an overjet was produced the tongue might come forward between the teeth against the contracted lower lip to seal off the increased overjet. He did not believe that any individual could swallow leaving a gap between the upper and the lower labial segments; they had to fill the gap, and they filled it partly by the lower lip and partly by the tip of the tongue. This tongue-thrusting behaviour reflexly produced, would be diagnosed as an atypical swallow, but he thought that, in fact, they ought to be called "habit activities", because it was likely that when the increased overjet was adjusted, the behaviour would disappear. In contrast to this, there was almost certainly another type of tongue-thrusting behaviour, probably endogenous in origin, which could not be controlled by the patient and would not disappear as the result of any form of treatment.

Mr. H. E. Wilson said he thought that the number of clinical types was far too small and he was sure

that Mr. Tulley would be able to add to them as time went on.

In his view, the problem had three main factors, the morphology, environment, and habit of the soft tissues, i.e., lip and tongue, and when these are related to variations of the skeletal pattern the possible permutations are very large; with all these combinations of the various factors it was difficult to assess the factor or factors operating at a given time in any patient and to what degree. In addition it was difficult to determine which factors cancelled, or were antagonistic to, each other and to what degree. He thought that the sorting out of the numerous clinical types would involve a great deal of work.

The President, referring to the last case shown in the film, asked whether the authors considered it to be a typical case of postural prenormal occlusion.

Mr. W. J. Tulley, in reply, said that the authors had asked Mr. Rix to open the discussion because they felt sure that he would bring out some of the more important points which they had missed.

He agreed with Mr. Rix that observations of behaviour in the critical time during eruption of the incisors were much more reliable than observations of the established behaviour which might be secondary to the malocclusion.

With regard to clinical typing, the authors had used it because they felt that the Society needed a general survey of the whole subject as it stood at the moment. Obviously they left many gaps and all sorts of permutations could be produced. From the scientific point of view clinical typing was necessary. He thought that from the teaching point of view it had a definite advantage, in presenting the interrelation between soft-tissue morphology, behaviour, and skeletal pattern.

Replying to the President, the Class III case shown in the film was a rather odd one. It was not a postural Class III. It was not possible for the patient to achieve an incisor edge-to-edge bite.

He agreed with most of Mr. Hovell's remarks. The case they had shown with bi-maxillary protrusion was not a typical bi-maxillary prognathism, but the facial skeleton was forward in relation to the cranial base. This could be judged by the SNA-SNB angles.

With regard to Mr. Ballard's remarks, he did not like the term "incompetent lip posture". (Mr. Hovell interposed that a better term might be "incompetent lip morphology".) Mr. Tulley said incompetent lips were lips which were not able to seal without a conscious effort; he accepted that. Lips, however, which were badly postured, e.g., separated by the incisors, might be able to seal when the teeth were moved and were therefore competent. He thought Mr. Ballard had said all that could be said on this particular aspect of the subject and the authors had deliberately omitted it in order not to confuse the issue.

He agreed with what Mr. Wilson had said about the difficulties of clinical typing. He had already said in reply to Mr. Rix that it was necessary in order to demonstrate some of the variations of facial form and function with which orthodontists had to deal in everyday practice.

Mr. E. Gwynne-Evans, in replying to the discussion, referred to Mr. Hovell's remarks and said that the lower animals had no sheet of muscle over the head and face.

Mr. Ballard had opened up a thorny problem in his reference to lip posture. Posture is a held attitude implying muscle tone, a feature of neuromuscular activity which had been rather dropped in our discussions recently in favour of considering muscle behaviour as a whole.

REPORTS OF MEETINGS

ORDINARY MEETING, January 10

An Ordinary Meeting of the Society was held at Manson House, 26, Portland Place, London, W.1, on Monday, January 10, 1955, at 7.30 p.m. Mr. K. E. Pringle, the President, occupied the chair.

The Minutes of the Annual General Meeting held on December 13, 1954, were read, confirmed, and signed.

The President, referring to the death of Sir Arthur Keith, said that Sir Arthur was a famous anatomist and anthropologist. He had been elected an Honorary Member of the Society in 1921 and was therefore one of the Society's oldest Honorary Members. In October, 1913, he had read a paper before the Society, entitled "Certain Factors in Tooth Eruption", and in 1921, with Mr. G. G. Campion, he had presented to the Society a paper entitled "A Contribution to the Mechanism of Growth of the Human Face". He had opened the discussion on Professor Brash's paper, "The Growth of the Alveolar Bone, etc." in 1926, and he had taken part in other discussions at the Society's meetings.

The members and visitors stood in silence for a few moments in memory of Sir Arthur Keith.

The Hon. Secretary (Mr. H. L. Leech) read a letter from the British Society of Periodontology inviting members of the British Society for the Study of Orthodontics to attend a meeting to be held at 5.0 p.m. on Monday, February 7, at the Eastman Dental Hospital, when a symposium on "Occlusal Equilibration in General Practice" would be held, the three principal contributors being Messrs. Hamish Thomson, R. J. G. Grewcock, and A. R. F. Thompson.

Mr. Lindo Levien then presented some copies of the Transactions of the Society to Mr. A. G. Taylor, the Honorary Librarian, for the Society's Library.

The President welcomed the visitors who were present and invited them to take part in the discussion on his Address.

The following recently elected members signed the Obligation Book and were introduced to the President, who admitted them to membership of the Society: Mr. S. W. Edworthy, Mr. Kenneth Lees, and Mr. J. F. Reading.

The following candidates for membership of the Society were elected *en bloc* by show of hands:—

Mr. D. G. Gould, B.D.S. (Lond.), 36, Rutland Road, E.9;

Mr. J. G. Suckling, B.D.S. (N.Z.), 22, Ladbroke Square, W.11;

Mr. B. Braude, D.D.S., M.D.S. (U.S.A.), 78, Pasteur Chambers, Jeppe Street, Johannesburg (Corresponding Member);

Mr. H. C. Volmer Lind, Folktandvarden Halmstad, Sweden (Corresponding Member).

The President said that he would like to thank the members for conferring upon him the greatest honour that could be given to a British orthodontist. He hoped that he would prove worthy of it.

At the last meeting of the Society he had been very pleased to be inducted into the office of President by Mr. Trevor Johnson, who had so genially conducted the Society's meetings during the past year. He would like the members to think also for a moment of Mr. Pilbeam, who had recently retired from the Council after many years of service upon it. He was sure all the members were very grateful to Mr. Pilbeam for his work as a Councillor and particularly as Editor during a very difficult time in the Society's history. (*Applause.*)

The President then delivered the Presidential Address:—

"*Long Term Results of Orthodontic Treatment*"

SPECIAL MEETING, February 14

A Special Meeting of the Society was held at Manson House, 26, Portland Place, London, W. 1, on Monday, February 14, 1955, at 7.20 p.m. Mr. K. E. Pringle, the President, occupied the Chair.

Mr. Howell Richards moved, on behalf of the Council, that Bye-law XXVI be amended to read as follows:—

"No sum of money exceeding Five Pounds shall be paid by the Treasurer, on account of the Society, unless such payment be previously sanctioned by the Council; and all cheques for Fifty Pounds and over shall be countersigned by the Honorary Secretary."

At the present time, he said, the Bye-law read as follows: "No sum of money exceeding Five Pounds shall be paid by the Treasurer, on account of the Society, unless such payment be previously sanctioned by the Council", and it was now proposed that the words "and all cheques for Fifty Pounds and over shall be countersigned by the Honorary Secretary" should be added. In case it might be thought that these words were some reflection upon the Honorary Treasurer, he would like to say that the amendment had been first put forward by a former Honorary Treasurer, but owing to the ineptitude of the then Honorary Secretary it had not been put before the General Meeting at the end of the year. During the last two or three years it had been the practice for all cheques for £50 and over to be countersigned by the Honorary Secretary, and as the Bye-laws were about to be reprinted it was proposed that this provision should be incorporated in them.

The Hon. Treasurer (Mr. J. S. Beresford) seconded the motion.

The motion was carried unanimously.

The meeting then terminated.

ORDINARY MEETING, February 14

An Ordinary Meeting of the Society was held at Manson House, 26, Portland Place, London, W.1, on Monday, February 14, 1955, at 7.30 p.m. Mr. K. E. Pringle, the President, occupied the Chair.

The Minutes of the previous meeting, held on January 10, 1955, were read, confirmed, and signed.

The Hon. Secretary reminded the members that the country meeting would be held at the Dental School, Sheffield, May 5–8. Provisional programmes had been printed and would be sent to all members of the Society some time during the present week. There was a portion to be filled in by members who intended to be present at the meeting, indicating which of the various functions they proposed to attend, and these slips should be detached and sent in before March 10. The members attending the meeting should book their hotel accommodation direct and not through the Society.

The President welcomed the visitors who were present and invited them to take part in the discussions and consider themselves as members of the Society for the evening.

The following recently elected members were introduced to the President, who formally admitted them to membership, and they signed the Obligation Book: Mr. B. Braude, Mr. Ellis, and Mr. J. G. Suckling.

The following candidates for membership of the Society were elected *en bloc* by show of hands:—

Miss G. W. Brown, F.D.S., 8, Bryanston Street, London, W.1;

Miss R. Malik, B.D.S. (Lond.), 92, South Hill Park, Hampstead, London, N.W.3;

Miss D. R. Ridley, L.D.S., 34, Redford Avenue, Wallington, Surrey.

Mr. H. L. Leech then read the following short communication:—

"*Angle's Class II, Division 1 and Class II, Division 2 in Identical Twins*"

Dr. D. J. Anderson then read the following paper:—

"*The Physiology of Mastication*"

ORDINARY MEETING, March 14

An Ordinary Meeting of the Society was held at Manson House, 26, Portland Place, London, W.1, on Monday, March 14, 1955, at 7.30 p.m. Mr. K. E. Pringle, the President, occupied the Chair.

The Minutes of the last Ordinary Meeting and of the Special Meeting, held on February 14, 1955, were read, confirmed, and signed.

The President welcomed the visitors who were present and said he hoped they would take part in any discussions that might take place at the meeting.

The following candidates for membership of the Society were duly elected *en bloc* by show of hands:—

Miss S. R. Newell, B.D.S. (V.U. Manc.), Far Hills, Chester Road, Woodford, Cheshire;

Mr. J. C. Stephenson, B.D.S. (Lond.), 42, Trinity Church Square, London, S.E.1.

Mr. J. D. Hooper then read the following paper:—

"*Orthodontics in the Hospital Service*"

COUNTRY MEETING, May 6–7

A Country Meeting of the Society was held at the Charles Clifford Dental Hospital, Sheffield, on Friday and Saturday, May 6 and 7.

The President opened the Meeting by introducing Professor Roberts, whose Address of Welcome was generously received.

Over 100 members and visitors were present.

The minutes of the Ordinary Meeting held on March 14 were read, confirmed, and signed.

The President welcomed the visitors, and invited them to consider themselves members for the Meeting.

Mr. A. F. D. Shapland, Mr. K. J. Wilkie, and Miss D. R. Ridley were introduced to the President, and admitted to full membership of the Society.

The following candidates for membership were elected *en bloc* by show of hands:—

Mr. E. S. Broadway, F.D.S., 8, Dickens Rise, Chigwell, Essex;

Mr. D. A. Dixon, F.D.S., 18, Belvedere Road, Leyton, London, E.10;

Mr. H. G. Griffith, L.D.S., 16, College Road, Eastbourne.

The Chair was then taken over by Mr. H. Chapman, who introduced Mr. J. R. E. Mills and invited him to present the first Paper entitled: "*Ideal Dental Occlusion in the Primates*".

The discussion was opened by Mr. W. R. Burston. Mr. D. F. Glass and Professor G. E. M. Hallett also took part.

Mr. Mills replied. A vote of thanks proposed to him by Mr. Chapman was carried unanimously.

The President resumed the Chair and introduced Mr. H. L. Leech, who read a Short Paper entitled: "*Restorative Treatment of Anodontia in a Developing Child*".

Following discussion by the President, Mr. W. J. Tulley, and Mr. H. Chapman, Mr. Leech replied and was accorded a unanimous vote of thanks.

The afternoon session was opened by the President introducing Mr. W. A. Nicol, who read a Paper entitled: "*The Relationship of the Lip Line to the Incisor Teeth*".

The discussion was opened by Mr. J. H. Hovell, and Mr. M. A. Kettle, Miss L. M. Clinch, Mr. A. J. Walpole Day, and Mr. W. J. Tulley also took part.

Mr. Nicol replied and a vote of thanks proposed by the President was carried with acclamation.

The President then introduced Mr. D. T. Hartley and asked him to read his Short Paper: "*The Clinical Assessment of the Unerupted Maxillary Canine*".

Messrs M. A. Kettle, J. H. Hovell, H. G. Watkin, C. F. Ballard, N. Gray, H. Chapman, and A. J. Walpole Day took part in the discussion. Following his reply, Mr. Hartley was accorded a vote of thanks by the President which was supported unanimously.

Miss L. M. Clinch took the Chair for the final session of the day, and introduced Mr. S. G. McCallin, who read his Paper entitled: "*Angle's Class III Malocclusion*".

Mr. H. Chapman opened the discussion and Messrs. J. H. Hovell, M. A. Kettle, C. F. Ballard, D. T. Hartley, G. C. Dickson, P. Readings, J. Campbell, A. J. Walpole Day, H. E. Wilson, H. G. Watkin, A. C. Campbell, and Miss L. M. Clinch took part.

Mr. McCallin replied and a hearty vote of thanks proposed by Miss Clinch was carried with applause.

The Saturday morning session was comprised of a Symposium on the Temporomandibular Joint and Mandibular Movement. The President introduced the reader of the first Paper, Mr. R. Sprinz, who chose for his title "*A Contribution to the Functional Anatomy of the Mandibular Joint*".

The discussion was opened by Mr. W. J. Tulley; Messrs. J. Campbell, J. S. Beresford, and A. G. Taylor took part. Mr. Sprinz replied.

The PRESIDENT then introduced the second speaker, Mr. J. HOPPER, who read a Paper entitled: "*Preliminary Investigation of Mandibular Guidance in Postural Class III Cases*".

Messrs. J. H. Hovell, G. E. M. Hallett, and W. J. Tulley took part in the discussion and Mr. Hopper replied.

Mr. N. GRAY took the Chair for the final speaker, Mr. C. F. Ballard, who read his Paper: "*A Consideration of the Physiological Background of Mandibular Posture and Movement*".

Messrs. M. A. Kettle, W. Elgey, J. H. Hovell, W. J. Tulley, T. Jason Wood, P. Readings, J. R. E. Mills, and A. J. Walpole Day took part in the discussion and Mr. Ballard replied.

The PRESIDENT called for a vote of thanks to the three speakers and this was carried with acclamation.

At the Concluding Meeting the PRESIDENT proposed a hearty vote of thanks to all those who had made this, the first Country Meeting such a success, the readers of papers, demonstrators, and organizers, especially Mr. J. H. Gardiner and his colleagues of the Charles Clifford Dental Hospital. This was carried with prolonged applause.

The PRESIDENT then requested the views of the Society regarding the holding of another such Meeting next year, and asked members to convey them by letter to the Hon. Secretary.

The appreciation of the Society to the President for his work during the Meeting was expressed by Mr. H. Chapman and was supported unanimously by the members present.

A DEMONSTRATION MEETING was held in the afternoon, when the high standard of previous demonstrations was maintained by Messrs. J. Campbell, D. F. Glass, D. T. Hartley, A. G. Huddart, Miss R. Sclare, Messrs. B. R. Townend, H. G. Watkin, P. H. Burke, Professor G. E. M Hallett, Messrs. G. B. Hopkin, J. D. McEwen, W. H. Littlefield, E. K. Breakspear, H. L. Eirew, A. W. Greenwood, D. Logie, and T. Jason Wood.

Before dispersal, members of the Society were taken on conducted tours of the new dental hospital by members of the hospital staff.

ORDINARY MEETING, October 10

AN ORDINARY MEETING of the Society was held at Manson House, 26, Portland Place, London, W.1, on Monday, October 10, 1955, at 7.30 p.m. Mr. K. E. Pringle, President, occupied the Chair.

The Minutes of the first Provincial Meeting, held at Sheffield on May 6 and 7, 1955, were read, confirmed, and signed.

The SECRETARY (Mr. H. L. Leech) said that the Council had not received many Casual Communications this year and would be very glad to receive further ones.

The following candidates for membership of the Society, approved by the Council, were elected *en bloc* by show of hands:—

Dr. J. H. Scott, M.D., L.D.S., Anatomy Department, Queen's University, Belfast;

Mrs. D. Kolia, L.D.S., 81, Overhill Road, London, S.E.12.

The PRESIDENT welcomed the visitors who were present and said he hoped that they would take part in the discussion and consider themselves members for the evening.

MR. J. H. GARDINER then read the following paper:—

"*A Survey of Malocclusion and Some Aetiological Factors in* 1000 *Sheffield Schoolchildren*"

ORDINARY MEETING, November 14

AN ORDINARY MEETING of the society was held at Manson House, 26, Portland Place, London, W.1, on Monday, November 14, 1955, at 7.30 p.m. The President, Mr. K. E. Pringle, occupied the Chair.

The Minutes of the previous meeting, held on October 10, 1955, were read, confirmed, and signed.

Mr. J. C. Stephenson, a recently elected member, signed the Obligation Book and was admitted by the President to membership of the Society.

The following candidates for membership, approved by the Council, were elected *en bloc* by show of hands:—

Mrs. M. Alexander, L.D.S., Fern Cottage, 28, Hoyland Road, Hoyland Common, near Barnsley, Yorkshire;

Mr. L. F. Langford, L.D.S., (V.U. Manc.), The Firs Pavilion, Old Hall Lane, Fallowfield, Manchester, 14.

The PRESIDENT welcomed the visitors who were present and said he hoped they would regard themselves as members for the evening and would take part in the discussion if they wished to do so.

DR. L. H. WELLS then delivered the Ninth Northcroft Memorial Lecture on:—

"*The Form of the Jaws of Ancient and Modern Types in Man*"

ANNUAL GENERAL MEETING, December 12

THE ANNUAL GENERAL MEETING of the Society for the year 1955 was held at Manson House, 26, Portland Place, London, W.1, on Monday, December 12, 1955, at 7.0 p.m. Mr. K. E. Pringle, President, occupied the Chair.

The Minutes of the Ordinary Meeting held on Monday, November 14, were read, confirmed, and signed.

Election of Officers and Councillors.—No other nominations having been received, the following Officers and Councillors for 1956 nominated by the Council were declared by the President duly elected:—

President	Mr. J. H. Hovell
Immediate Past President	Mr. K. E. Pringle
Vice-Presidents	Mr. H. Chapman
	Mr. C. F. Ballard
	Mr. J. W. Softley
Hon. Secretary	Mr. H. L. Leech
Hon. Treasurer	Mr. J. S. Beresford
Hon. Librarian	Mr. A. G. Taylor
Hon. Editor	Mr. W. J. Tulley
Hon. Curator	Miss L. M. Clinch
Councillors	Mr. H. Richards
	Mr. J. H. Gardiner
	Mr. J. D. Hooper

Election of Two Auditors.—On the motion of Mr. R. E. Rix, seconded by Mr. J. D. Hooper, Mr. S. B. NEWTON and Mr. T. L. WINN were re-elected Auditors for the year 1956.

Report of the Hon. Treasurer.—The HON. TREASURER (Mr. J. S. Beresford) reported as follows:—

The excess of Income over Expenditure for the year has not been so great as last year. Several items of Expenditure are worthy of note. The Honoraria were paid to the young ladies who had served for a number of years as Secretaries to the Hon. Editor, Secretary, and Treasurer, and it is likely that similar payments will be made annually.

The Society has invested a further £1000, half in 4 per cent Consolidated Stock and half in $3\frac{1}{2}$ per cent Defence Bonds. The accounts indicate the incidental expenses of the Country Meeting less subscriptions received from the temporary members, but it is not yet known to what extent the publication of the additional papers read at that meeting will raise the cost of the Transactions for 1955. The 1953 Transactions which were published by Messrs. Saward and Co. cost £585, which is £141 more than had been reserved. The 1954 Transactions which were published by Messrs. John Wright & Sons cost £435, but this might have been reduced substantially if a sufficient number of the Society's members had subscribed to the *Dental Practitioner and Dental Record.*

On the motion of the HON. TREASURER, seconded by Mr. J. D. HOOPER, the report was received.

On the motion of the PRESIDENT, the report was adopted.

Report of the Hon. Secretary.—The HON. SECRETARY (Mr. H. L. Leech) reported as follows:—

During my first year as Hon. Secretary to this Society from December, 1954, to November, 1955, seven meetings have been held with an average attendance of 90 members and visitors per meeting.

This is a slight drop on the figures for the previous year, in spite of the fact that the attendance at the Country Meeting in May was most encouraging, 101 members and visitors being present.

During the year 17 new members have been elected. This again is less than last year, although there are 9 candidates awaiting election in the New Year. There have been 4 resignations and 2 deaths, and the membership as at December 31 is expected to be 409.

The first Country Meeting of the Society was held in May at Sheffield, and took the form of a two-day conference. The amenities

of the Charles Clifford Dental Hospital were very kindly placed at the Society's disposal by permission of the Dean, Professor G. L. Roberts, who opened the meeting with an Address of Welcome.

The local organization was expertly carried out by Mr. J. H. Gardiner, whose help and co-operation greatly reduced the burden placed on the Hon. Secretary.

Eight papers were read, including a Symposium on the Temporomandibular Joint, and seventeen table demonstrations were given.

So successful was this meeting that the Council has decided to hold another one in May next year, and the facilities of the Sutherland Dental School, Newcastle, have been kindly offered by Professor R. V. Bradlaw and Professor G. E. M. Hallett and gratefully accepted.

On the motion of the HON. SECRETARY, seconded by Mr. J. H. HOVELL, the report was received.

On the motion of the PRESIDENT, the report was adopted.

Report of the Hon. Librarian.—The HON. LIBRARIAN (Mr. A. G. Taylor) reported as follows:—

The number of items lent to members this year is a record and almost equals the last two years put together.

The number of items presented to the library this year is so great that my report will be unusually long. They include:—

From Mr. Chapman and Mr. Wilson:—

Angle, H. E.: *Some New Forms of Orthodontic Mechanism and the Reasons for their Introduction and Orthodontia—The Ribbon Arch Mechanism and Some New Auxiliary Instruments.*

Clinch, L.: *Variations in the Degree of Overbite between Birth and Three Years.*

Friel, S.: *The Teaching of Orthodontics, Graduate and Postgraduate.*

Graber, T. M.: *The Fundamentals of Occlusion.*

Izard, G.: *Terminologie descriptive des Malpositions dentaires et des Deformations maxillofaciale.*

James, W. W., and Hastings, S.: *Discussion on Mouth Breathing and Nasal Obstruction.*

Lischer, B. E.: *Anent Recent Tendencies in Orthodontic Theory and Practice.*

McCoy, J. D.: *A Plea for the Better Understanding of the Orthodontic Problem.*

Northcroft, G.: *Report on the Problem of Retention with a View to Performance of Result and Minimum of Danger.*

Pont, A.: *Diagnostic et Traitement de la Voûte ogivale.*

Sippy, B. O.: *The Importance of Space Retention in Maintaining Occlusion.*

Taylor, A. T.: *A Study of the Incidence and Manifestations of Malocclusion and Irregularity of the Teeth.*

Waugh, L. M.: *The Value of the Roentgen Ray in Orthodontia.*

Willett, R. C.: *Periodic Treatment of Malocclusion.*

From Mon. H. Brabant:—

Brabant, H.: *Que nous apprend l'Étude des Dents contenues dans les Kystes demoides ovariens?*

Brabant, H.: *Nouvelles Observations de Retention partielle ou totale de Molaires temporaires ou definitives.*

From La Société Française d'Orthopédie Dento-Faciale:—

L'Orthodontie française, 1954.

From the Reprint Service of the Canadian Dental Association:—

Hunter, H. A.: *A Study of Tissues treated with Antiformin-citric Acid.*

Popovich: *Cephalometric Evaluation of Vertical Overbite in Young Adults.*

From the British Society of Periodontology:—

Proceedings of the Society for 1954.

From Lindo Levien:—

Six issues of the *Transactions.*

From the President:—

Sixteen issues of the *Transactions* and four issues of the *Transactions of the E.O.S.*

Björk, A.: *The Face in Profile*, 1947.

Keene and Whillis: *Anatomy for Dental Students*, 1950.

Posselt, U.: *Studies in the Mobility of the Human Mandible.*

Selmer-Olsen, R.: *An Odontometrical Study of the Norwegian Lapps*, 1949.

Wallace, J. S.: *Variations in the Form of the Jaws*, 1927.

The Society is indeed lucky to have such generous members and friends and this is my opportunity to say "Thank you" to them in the presence of the Society.

Besides lending and acquiring books and periodicals dealing with orthodontics, the library sells current and past issues of the *Transactions* and the 1954 *Transactions* have been sold in greater numbers than any previous issue. Mostly these *Transactions* go to dental school libraries, ten copies to North America, and others to Scandinavia, New Zealand, Australia, and elsewhere. The list of donors to the library in conjunction with the distribution of the *Transactions* shows how high is the reputation of the Society and how international is the spirit of orthodontics.

Every other year someone asks for a complete set of past *Transactions*, but several issues are out of print and only broken sets can be supplied now with a promise that they will be made up if the missing numbers come to hand. I want to close with an appeal to members for their old *Transactions*, in particular those for the 1940s, 1927, and 1923.

On the motion of the HON. LIBRARIAN, seconded by Mr. H. RICHARDS, the report was received.

The HON. TREASURER expressed his appreciation of Mr. Taylor's efforts in selling the *Transactions* of the Society.

On the motion of Mr. W. J. TULLEY, seconded by Mr. R. E. RIX, the report was adopted.

Report of the Hon. Editor.—The HON. EDITOR (Mr. W. J. TULLEY) reported as follows:—

I am pleased to be able to report that we are now up to date with our *Transactions*. Both the 1953 and 1954 copies have been received by members this year. Thanks are due to the untiring efforts of Mr. Ballard in hustling Messrs. Saward, who published the 1953 copies, and to the excellent liaison we have with Messrs. Wright, of Bristol, who provided the new form of *Transactions* for 1954.

I must thank Mr. Ballard for carrying on for some months of this year in order to see the 1954 *Transactions* through.

There has been a considerable increase in the number of papers following the Country Meeting in Sheffield—fourteen instead of the usual six. All but one of the Sheffield papers have been printed or are with the printers, and précis of the discussion are printed in the *Dental Practitioner and Dental Record.*

Mr. Ballard stressed last year, and I would like to say it again, that now that Messrs. Wright are printing our proceedings, papers can be got into print quite quickly if readers will produce them according to the regulation laid down (that is, one week after reading). With this co-operation there is no reason why the 1955 *Transactions* should not be ready early in the New Year. A total of 181 members now subscribe to the *Dental Practitioner and Dental Record* and more are encouraged to subscribe.

I would like to move the adoption of this report.

On the motion of the HON. EDITOR, seconded by Mr. S. E. WALLIS, the report was received.

The PRESIDENT said he was glad that Mr. Tulley had referred to the work which Mr. Ballard had done in getting the Society out of the difficult situation in which it had been in the past. He was sure that the Council was much happier with the present arrangements than it had been with those which had obtained during the past few years.

Mr. R. E. RIX asked whether there was any limitation on the number of illustrations which could be accepted with papers.

Mr. W. J. TULLEY replied that there were limits to the number of ordinary prints which Messrs. John Wright and Sons would accept, but they were prepared to accept almost any number of line drawings, which were very much cheaper to reproduce.

A member asked whether non-members of the Society could buy the *Transactions.*

Mr. A. G. TAYLOR said there was only one non-member in this country who got the *Transactions* by paying for them. Otherwise, apart from members of the Society, the only people who got the *Transactions* were individuals abroad and the dental schools.

On the motion of Mr. C. F. Ballard, seconded by Mr. R. E. Rix, the report was adopted.

Report of the Hon. Curator.—The Hon. Curator (Miss L. M. Clinch) reported as follows:—

Models were received during the year from Miss Still (gemination of permanent upper incisors) and Mr. Leighton (supernumerary incisors in the deciduous dentition). A plate which had been repaired by a patient, aged 12, with excellent results was received from Mr. Risk.

The Museum is still housed in the Institute of Public Health and Hygiene (next door to Manson House) and can be seen between 10 a.m. and 5 p.m. on week-days.

On the motion of the Hon. Curator, seconded by Mr. S. G. McCallin, the report was received.

On the motion of the President, the report was adopted.

Election of Honorary Member.—The President, in moving that, in accordance with the recommendation of the Council, Dr. Lilian Lindsay be elected an Honorary Member of the Society, said that for many years Dr. Lindsay had rendered very great services to the Society.

The motion was carried with applause.

The President said that he proposed to write to Dr. Lindsay saying that the members very much appreciated all that she had done for the Society and that she would always be welcomed at its meetings.

Election of Corresponding Member.—Mrs. K. Aslund, L.D.S. (Sweden), Kungsgatan 16b, Kalmar, Sweden, was elected as a Corresponding Member of the Society.

This concluded the business of the Annual General Meeting, and visitors were then admitted. The President welcomed them and expressed the hope that they would take part in the discussion if they wished to do so.

Mr. E. Gwynne-Evans and Mr. W. J. Tulley then read the following papers:—

"*Clinical Types*"

On the motion of the President, a vote of thanks was accorded to Mr. Gwynne-Evans and Mr. Tulley for their papers and film.

Mr. D. F. Glass, in moving a vote of thanks to Mr. Pringle for all that he had done for the Society during his year of office as President, said that the past year had been a very successful one. For the first time a meeting had been held in the provinces, at Sheffield, and it had been so successful that there was no doubt that in future meetings in the provinces would be a regular feature of the Society's activities. The thanks of the members were due in particular to Mr. Pringle for all that he had done in connexion with the meeting at Sheffield.

The vote of thanks was accorded with applause.

The President, in responding, thanked the Council and the members in general for the way in which they had supported him during his year of office. In particular he thanked Mr. Leech for his valuable services during his first year of office as Hon. Secretary.

The President then invested Mr. J. H. Hovell, the President for 1956, *with the President's badge of office.*

Mr. J. H. Hovell thanked the members for the honour which they had conferred upon him in electing him as President of the Society.

The meeting then terminated.

THE BRITISH SOCIETY FOR THE STUDY OF ORTHODONTICS

Balance Sheet and
Income and Expenditure Account

FOR THE YEAR ENDED SEPTEMBER 30, 1955

FREDK. B. SMART & COMPANY, CHARTERED ACCOUNTANTS
22 Queen Street, London E.C.4

The British Society for the Study of Orthodontics

BALANCE SHEET as at 30th September, 1955.

1954 £ s. d.		£ s. d.	£ s. d.
	Accumulated Fund:—		
	Balance at 1st October, 1954 ..	2,445 13 7	
	Add Excess of Income over Expenditure for the year	328 5 11	
2,445 13 7			2,773 19 6
	Creditors:—		
950 0 0	Transactions Balance 1954 and 1955 (Estimated by the Honorary Treasurer)	850 0 0	
26 5 0	Northcroft Memorial Lecture ..	26 5 0	
27 0 0	Hire of Hall	19 13 0	
7 17 6	Museum Rent	7 17 6	
12 0 0	Refreshments	—	
9 10 10	Subscriptions in Advance ..	7 18 0	
1 17 0	Sundry Expenses	—	
			911 13 6
£3,480 3 11			£3,685 13 0

S. B. NEWTON } *Hon. Auditors.*
T. L. WINN }
J. S. BERESFORD, *Hon. Treasurer.*

1954 £ s. d.		£ s. d.	£ s. d.
	Furniture and Equipment:—		
	Balance at 1st October, 1954 ..	366 18 0	
	Add Projector	72 11 0	
		439 9 0	
	Less Depreciation at 5% per annum	34 4 0	
366 18 0			405 5 0
9 9 0	*Debtors*		
	Investments:—		
	500 National Savings Certificates Seventh Issue at Cost	375 0 0	
	Add Accrued Interest	100 0 0	
462 10 0		475 0 0	
575 14 0	£691 5s. 10d. 2½% Consolidated Stock at Cost	575 14 0	
	£500 0s. 0d. 4% Consolidated Stock at Cost	485 6 3	
	£500 0s. 0d. 3½% Defence Bonds at Cost	500 0 0	
	(Approximate Market Value £1,811)		2,036 0 3
	Cash at Bank:—		
693 12 2	Westminster Bank, Ltd.	322 5 10	
1,370 10 2	Post Office Savings Bank ..	919 8 11	
			1,241 14 9
	Cash in Hand:—		
9 10	Honorary Treasurer	2 8 10	
1 0 9	Honorary Secretary	4 2	
			2 13 0
£3,480 3 11			£3,685 13 0

Certified in accordance with the Books and Vouchers of the Society.
We have verified the Investments and Cash at Bank.

FREDK. B. SMART & CO.,
Chartered Accountants,
22, Queen Street, London, E.C.4.

18*th November*, 1955.

The British Society for the Study of Orthodontics

INCOME AND EXPENDITURE ACCOUNT for the year ended 30th September, 1955.

1954 £ s. d.		£ s. d.	£ s. d.
10 10 0	To Museum Rent		10 10 0
83 17 1	,, Printing and Stationery	92 7 1	
444 1 1	,, Reserve for Cost of Transactions	584 7 8	
			676 14 9
24 11 10	,, Postage	18 5 3	
3 1 0	,, Lantern and Film Expenses ..	1 5 0	
54 0 0	,, Hire of Hall	46 13 0	
51 9 0	,, Reporting	32 16 5	
67 12 0	,, Refreshments	53 10 0	
– – –	,, Country Meeting net Cost ..	12 8 2	
			164 17 10
8 8 0	,, Audit and Accountancy ..		8 8 0
3 8 6	,, Insurance		4 4 6
8 13 6	,, Library and Journals		4 17 6
26 5 0	,, Northcroft Memorial Lecture ..		26 5 0
– – –	,, Honoraria		42 0 0
10 6 0	,, Sundry Expenses		11 15 9
30 11 6	,, Depreciation on Furniture and Equipment		34 4 0
465 9 4	,, *Excess of Income over Expenditure for the year*		328 5 11
£1,292 3 10			£1,312 3 3

1954 £ s. d.		£ s. d.	£ s. d.
	By *Members' Subscriptions:—*		
	1955 Subscriptions	1,106 19 2	
1,156 11 6	Adjustment in respect of Past Years	34 14 10	
			1,141 14 0
73 8 10	,, Sale of Transactions		84 0 1
12 10 0	,, Accrued Interest on Savings Certificates		12 10 0
17 5 4	,, Interest on $2\frac{1}{2}$% Consolidated Stock		17 5 4
– – –	,, Interest on 4% Consolidated Stock		10 0 0
– – –	,, Interest on $3\frac{1}{2}$% Defence Bonds		12 8 10
32 8 2	,, Interest on Post Office Savings Bank Account		34 5 0
£1,292 3 10			£1,312 3 3

SUBJECT INDEX

AUTHOR INDEX